Drum, Loyka & Associates, LLC
CIVIL ENGINEERS - LAND SURVEYORS

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Griscom Square
Concept Storm Drainage & Stormwater Management Narrative & Computations

Tax Map: 15G, Grid 7, Parcels 761-764

FCP2015-002

Prepared for: Mr. John Pilli

Date: August 2015

STATE OF MARYLAND
MICHAEL M. DRUM
No. 18521
PROFESSIONAL ENGINEER

8/27/15

Michael M. Drum, P.E.
#18521

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I. Existing Conditions

The subject property consists of approximately 3.05 acres of land, located at the corner of Tyler Avenue and Bay Ridge Avenue in the City of Annapolis. The site is zoned R2 and is not located in the Critical Area. There are no wetlands on site. The property originally consisted of Parcels 761, 762 and part of Parcel 764; now subdivided into 12 residential lots via record plat entitled "Griscom Square", recorded among the Land Records of Anne Arundel County in Plat Book 330, Pages 12-13, Plat Numbers 17038-17039.
There are two existing houses on the property that will remain and be renovated as part of the development. The site is mostly gently sloping open space lawn with several large trees and scattered woods in the southwest section of the site. There are areas of ponding behind Parcel 764 that will be corrected as a result of construction of the proposed storm drain system.

Resources for the existing site include:

(a) **Primary Environmental Features identified on-site:**
- (i) **Streams** - There are no streams located on the site.
- (ii) **Stream Order** - N/A
- (iii) **Stream Buffers** – N/A
- (iv) **Wetlands & Wetland Buffers** - There are no wetlands or wetland buffers present on site.
- (v) **Floodplain** – The subject property is not affected by any known floodplains. The site is located in Zone X-Unshaded per FEMA FIRM Map Panel 24003C0253F.
- (vi) **Steep Slopes** - There are no steep slopes on site, as defined in Title 17, Chapter 04 of the City Code.

(b) **Secondary Environmental Features identified on-site:**
- (i) **Critical Area** - The subject property is not located within the Chesapeake Bay Critical Area.
- (ii) **Soils** - The subject property is comprised of Annapolis-Urban land complex, 0 to 5% slopes (AuB). This soil has a Type C hydrologic classification. This soil type is not considered hydric or highly erodible.
- (iii) **Forests** – The site contains areas classified as forest. See the included Forest Stand Delineation plan.
- (iv) **Cultural Resources** – No archaeological resources, historic structures, or historic sites are known to exist on the subject property.
- (v) **Miscellaneous** – No miscellaneous topographic features are known to exist on-site.

II. Proposed Condition

The proposed community will have twelve lots with ten new homes, several areas of community open space, and two new roads, Hopkins Street and Griscom Way. It will also include several off-street parking spaces and sidewalks connecting the various areas of open space. Public water and public sewer will serve this development, with proposed extensions for each.

Storm Drainage will be provided to convey runoff from the upstream drainage area to the west. The proposed Storm Drainage will tie into the existing system at the intersection of Tyler Avenue and Bay Ridge Avenue. That existing system eventually outfalls at Back Creek. A downstream photo tour is included in this report.

Stormwater Management is applied using Environmental Site Design to the maximum extent practical. There are 6 drainage areas within the site. Each drainage area is addressed individually with micro-practices specific to their needs.

III. Stormwater Management Design

The overall concept for stormwater management and Environmental Site Design is to minimize impervious surfaces, optimize the conservation of the site's natural resources, and minimize the impact of the development on the surrounding area. For Griscom Square, the design addresses this in several ways. Micro-practices are utilized to treat run-off at the source, and flat lawn areas are provided to maximize opportunities for infiltration and evapotranspiration of runoff. The stormwater management design is integrated with the storm drain design for comprehensive rainwater management.

Soils for the property are classified as Annapolis-Urban Land complex (AuB), which has a type 'C' hydrological designation. Marshall Engineering, INC., and O'Berry Engineering, INC., geotechnical engineers, performed a series of soil borings across the property to further define the physical soil properties. Their findings, detailed in the attached geotechnical reports, indicated that certain sections of the property were conducive to providing subsurface infiltration. The design utilizes that information to incorporate infiltration practices where site conditions allow.

The target RCN for "woods in good condition" for the development area is 70. The proposed imperviousness for the development area is 43%. Utilizing Table 5.3 from the State Manual, a target rainfall depth of 1.8" and a target runoff depth of 0.77" were determined. From these initial computations, a minimum Environmental Site Design Volume of 8,582 c.f. of runoff would need to be managed, of which 620 c.f. would need to be Recharge Volume.

The property was broken down into 6 distinct drainage areas. In accordance with MDE's 2000 Maryland Stormwater Design Manual, Volumes 1 & 2, stormwater management requirements are addressed for each drainage area. The computations for the total development and each drainage area are provided. The total provided ESD Volume provided is 9,991 c.f. and the total provided Recharge Volume is 2,552 c.f. Those volumes meet or exceed the required volumes, and so ESD is achieved to the MEP for the development.

Drum, Loyka, & Associates LLC

Designer: DE	Date: August 21, 2015	Checked By: WB	Date:
Title: Griscom Square			Job No.: BP12804
Subject: ESD Design			Sheet No. of

Site Data (Site Area):

Location: Tyler Avenue, Annapolis, MD							
Site Area (DA):		133,060 sf	or	3.05 Ac.			
Disturbed Area Onsite :		116,560 sf	or	2.68 Ac.			
Soils:	HSG 'A' =	0 sf	or	0 Ac.	or	0 %	of Site
	HSG 'B' =	0 sf	or	0 Ac.	or	0 %	of Site
	HSG 'C' =	133,060 sf	or	3.05 Ac.	or	100 %	of Site
	HSG 'D' =	0 sf	or	0 Ac.	or	0 %	of Site

Total Hard Surfaces =	56,649 sf	or	1.30 Ac.

Step 1: Determine ESD Implementation Goals

A. Determine Pre-Developed Conditions:

Soil Conditions and RCNs for "woods in good condition"

HSG	RCN*	Area	Percent
A	38	0.00 Ac.	0.00
B	55	0.00 Ac.	0.00
C	70	3.05 Ac.	100.00
D	77	0.00 Ac.	0.00

* RCN for "woods in good condition" *(Table 2-2, TR-55)*

** Actual RCN is less than 30, use RCN = 38

Composite RCN for "woods in good condition"

RCN_{woods} = [(38x0.00ac)+(55x0.00ac)+(70x3.05ac)+(77x0.00ac)] / 3.05ac

RCN_{woods} = 70

Target RCN for "woods in good condition" = $\boxed{70}$

B. Determine Target P_E Using Table 5.3

P_E = Rainfall used to size ESD practices

Proposed imperviousness (%I)

Proposed Impervious Area: 56,649 sf *from Site Data Table, above*

%I = Imp. Area / Drainage Area = 56,649sf / 133,060sf = 42.57 % = $\boxed{43\ \%}$

- Determine P_E from Table

Hydrologic Soil Group 'A'										
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	40									
5%	43									
10%	46									
15%	48	**38**								
20%	51	40	**38**	**38**						
25%	54	41	40	39						
30%	57	42	41	39	**38**					
35%	60	44	42	40	39					
40%	61	44	42	40	39					
45%	66	48	46	41	40					
50%	69	51	48	42	41	**38**				
55%	72	54	50	42	41	39				
60%	74	57	52	44	42	40	**38**			
65%	77	61	55	47	44	42	40			
70%	80	66	61	55	50	45	40			
75%	84	71	67	62	56	48	40	**38**		
80%	86	73	70	65	60	52	44	40		
85%	89	77	74	70	65	58	49	42	**38**	
90%	92	81	78	74	70	65	58	48	42	**38**
95%	95	85	82	78	75	70	65	57	50	39
100%	98	89	86	83	80	76	72	66	59	40

Use P_E = 0.0 inches of rainfall as the target for ESD implementation

Hydrologic Soil Group 'B'										
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	61									
5%	63									
10%	65									
15%	67	**55**								
20%	68	60	**55**	**55**						
25%	70	64	61	58						
30%	72	65	62	59	**55**					
35%	74	66	63	60	56					
40%	75	66	63	60	56					
45%	78	68	66	62	58					
50%	80	70	67	64	60					
55%	81	71	68	65	61	**55**				
60%	83	73	70	67	63	58				
65%	85	75	72	69	65	60	**55**			
70%	87	77	74	71	67	62	57			
75%	89	79	76	73	69	65	59			
80%	91	81	78	75	71	66	61			
85%	92	82	79	76	72	67	62	**55**		
90%	94	84	81	78	74	70	65	59	**55**	
95%	96	87	84	81	77	73	69	63	57	
100%	98	89	86	83	80	76	72	66	59	**55**

Use P_E = 0.0 inches of rainfall as the target for ESD implementation

Hydrologic Soil Group 'C'										
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	74									
5%	75									
10%	76									
15%	78									
20%	79	**70**								
25%	80	72	**70**	**70**						
30%	81	73	72	71						
35%	82	74	73	72	**70**					
40%	84	77	75	73	71					
45%	85	78	76	74	71					
50%	86	78	76	74	71					
55%	86	78	76	74	71	**70**				
60%	88	80	78	76	73	71				
65%	90	82	80	77	75	72				
70%	91	82	80	78	75	72				
75%	92	83	81	79	75	72				
80%	93	84	82	79	76	72				
85%	94	85	82	79	76	72				
90%	95	86	83	80	77	73	**70**			
95%	97	88	85	82	79	75	71			
100%	98	89	86	83	80	76	72	**70**		

Use P_E = 1.8 inches of rainfall as the target for ESD implementation

Hydrologic Soil Group 'D'										
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	80									
5%	81									
10%	82									
15%	83									
20%	84	**77**								
25%	85	78								
30%	85	78	**77**	**77**						
35%	86	79	78	78						
40%	87	82	81	79	**77**					
45%	88	82	81	79	78					
50%	89	83	82	80	78					
55%	90	84	82	80	78					
60%	91	85	83	81	78					
65%	92	85	83	81	78					
70%	93	86	84	81	78					
75%	94	86	84	81	78					
80%	94	86	84	92	79					
85%	95	86	84	82	79					
90%	96	87	84	82	79	**77**				
95%	97	88	85	82	80	78				
100%	98	89	86	83	80	78	**77**			

Use P_E = 0.0 inches of rainfall as the target for ESD implementation

Compute Composite P_E:

HSG	Area	Target P_E		Net P_E
A	0.00 ac	0.0	0.00 ac x 0.00 / 3.05 ac =	0.0
B	0.00 ac	0.0	0.00 ac x 0.00 / 3.05 ac =	0.0
C	3.05 ac	1.8	3.05 ac x 1.80 / 3.05 ac =	1.8
D	0.00 ac	0.0	0.00 ac x 0.00 / 3.05 ac =	0.0
			Composite P_E =	**1.8**

C. Compute Q_E:

Q_E = Runoff depth used to size ESD practices

$Q_E = P_E * R_V$, where:

P_E = 1.8 in *(from above)*

R_V = 0.05 + (0.009)(I); I = 42.57 %

= 0.05 + 0.009 x (42.57)

= 0.43

Q_E = 1.8 " x 0.43

= **0.77 inches**

ESD Target for the Project

P_E = 1.8 Inches *composite P_E, from above*

Q_E = 0.77 Inches

D. Compute Target ESD_V & Re_V for Site:

Required Environmental Site Design Volume (ESD_V) for Site:

ESD_V = [(P_E) x (R_V) x (SITE)]/ 12

where: Target P_E = 1.80 in. *(from Table 5.3, above)*

R_V = 0.43 *(from Q_E, above)*

DA = 133,060 sf or 3.05 ac *(from Site Tabulations, above)*

Target ESD_V = [(1.80 in.) x (0.43) x (133,060 sf)] / 12 =

= **8,582 cf**

Required Minimum Recharge Volume (Re_V) for Site:

Re_V = [(S) x (R_V) x (SITE)]/ 12

Where:

Composite 'S' =

HSG	Area		Recharge Factor		Net 'S'
A	0.00	ac	0.38	0.00 ac x 0.38 / 3.05 ac	0.00
B	0.00	ac	0.26	0.00 ac x 0.26 / 3.05 ac	0.00
C	3.05	ac	0.13	3.05 ac x 0.13 / 3.05 ac	0.13
D	0.00	ac	0.07	0.00 ac x 0.07 / 3.05 ac	0.00
				Composite 'S' =	**0.13**

R_V = 0.43 *from WQ_V, above*

DA = 133,060 sf or 3.05 ac

Min. Re_V = [(0.13) x (0.43) x (133,060)] /12

= **620 cf**

E. Compute P_E Value & ESD_V or Project

Microscale & Non-Structural Practices							
DA #	ESD Practice	DA	ESD_V	Re_V	P_E Value	Weighted P_E Value	
1	Drainage Area 1	17,269 sf	1,094 cf	317 cf	1.80 in.	1.80" x 17,269 sf / 133,060 sf =	0.23 in.
2	Drainage Area 2	89,905 sf	6,865 cf	1,662 cf	1.90 in.	1.90" x 89,905 sf / 133,060 sf =	1.28 in.
3	Drainage Area 3	25,140 sf	1,050 cf	157 cf	1.70 in.	1.70" x 25,140 sf / 133,060 sf =	0.32 in.
4	Drainage Area 4	22,907 sf	307 cf	41 cf	1.00 in.	1.00" x 22,907 sf / 133,060 sf =	0.17 in.
5	Drainage Area 5	9,666 sf	290 cf	287 cf	1.40 in.	1.40" x 9,666 sf / 133,060 sf =	0.10 in.
6	Drainage Area 6	7,732 sf	385 cf	88 cf	1.90 in.	1.90" x 7,732 sf / 133,060 sf =	0.11 in.
		Totals:	**9,991 cf**	**2,552 cf**		**Total Weighted P_E Value =**	**2.2 in.**
		Targets:	**8,582 cf**	**620 cf**		**Target P_E =**	**1.8 in.**
		ESD_V Provided:	**9,991 cf**				
		Additional Q_P Storage:	**0 cf**				
	P_E Achieved =	**$(12 \times ESD_V)/(R_V \times AREA)$**		**= (12 x 9,991c.f.) / (0.43 x 133,060sf) =**			**2.1 in.**

III-a. Environmental Site Design – Drainage Area #1

Drainage Area #1 is located on the eastern half of the property, and is comprised of portions of lot 1, 2, 3, lot 10, and a portion of open space. This area drains toward and outfalls at the southern property line. Each lot has a small ESD practice to manage runoff from the proposed dwellings. A micro-bioretention device collects and manages overflow from the lots, as well as runoff from the shared driveway. The proposed storm drain system will convey overflow to the existing storm drain system in Bay Ridge Avenue.

Soils in this drainage area have a type "C" hydrologic classifications; the Target RCN for "woods in good condition" is 70. The proposed imperviousness for the development area is 41%. Utilizing Table 5.3 from the State Manual, a target rainfall depth (P_E) of 1.8" and a target runoff depth (Q_E) of 0.76" were determined. From these initial computations, a minimum Environmental Site Design Volume (ESD_V) of 1,088 c.f. of runoff would need to be managed, of which 79 c.f. would need to be Recharge Volume (Re_V).

ESD for this drainage area is achieved through the disconnection of rooftop and non-rooftop runoff, a rain garden, two drywells, and two micro-bioretention devices. The ESD_V provided is 1,094 c.f., and the Re_V is 317 c.f. Both of these volumes are greater than the targets, and therefore, ESD is achieved to the MEP. The proposed development mimics "woods in good conditions" and satisfies channel protection obligations through the Reduced Runoff Curve Number Method.

Drum, Loyka, & Associates LLC

Designer: DE	Date: August 21, 2015	Checked By: WB	Date:
Title: Griscom Square			Job No.: BP12804
Subject: ESD Design			Sheet No. of

Site Data (Drainage Area 1):

Location: Tyler Avenue, Annapolis, MD							
Drainage Area (DA):		17,269 sf	or	0.4 Ac.			
Soils:	HSG 'A' =	0 sf	or	0 Ac.	or	0 %	of Site
	HSG 'B' =	0 sf	or	0 Ac.	or	0 %	of Site
	HSG 'C' =	17,268 sf	or	0.4 Ac.	or	100 %	of Site
	HSG 'D' =	0 sf	or	0 Ac.	or	0 %	of Site

Proposed Impervious Surfaces	=	6,944 sf	or	0.16 Ac.
Proposed Alternative Surfaces	=	0 sf	or	0.00 Ac.
Existing Off-site Impervious Surfaces	=	153 sf	or	0.00 Ac.
Proposed Hard Surfaces	=	7,097 sf	or	0.16 Ac.

Step 1: Determine ESD Implementation Goals

A. Determine Pre-Developed Conditions:

Soil Conditions and RCNs for "woods in good condition"

HSG	RCN*	Area	Percent
A	38	0.00 Ac.	0.00
B	55	0.00 Ac.	0.00
C	70	0.40 Ac.	99.99
D	77	0.00 Ac.	0.00

* RCN for "woods in good condition" *(Table 2-2, TR-55)*

** Actual RCN is less than 30, use RCN = 38

Composite RCN for "woods in good condition"

RCN_{woods} = [(38x0.00ac)+(55x0.00ac)+(70x0.40ac)+(77x0.00ac)] / 0.40ac

RCN_{woods} = 70

Target RCN for "woods in good condition" = $\boxed{70}$

B. Determine Target P_E Using Table 5.3

P_E = Rainfall used to size ESD practices

Proposed imperviousness (%I)

Proposed Impervious Area: 7,097 sf *from Site Data Table, above*

%I = Imp. Area / Drainage Area = 7,097sf / 17,269sf = 41.1 % = $\boxed{41\ \%}$

- Determine P_E from Table

Hydrologic Soil Group 'A'											
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	40									
5%	43									
10%	46									
15%	48	**38**								
20%	51	40	**38**	**38**						
25%	54	41	40	39						
30%	57	42	41	39	**38**					
35%	60	44	42	40	39					
40%	61	44	42	40	39					
45%	66	48	46	41	40					
50%	69	51	48	42	41	**38**				
55%	72	54	50	42	41	39				
60%	74	57	52	44	42	40	**38**			
65%	77	61	55	47	44	42	40			
70%	80	66	61	55	50	45	40			
75%	84	71	67	62	56	48	40	**38**		
80%	86	73	70	65	60	52	44	40		
85%	89	77	74	70	65	58	49	42	**38**	
90%	92	81	78	74	70	65	58	48	42	**38**
95%	95	85	82	78	75	70	65	57	50	39
100%	98	89	86	83	80	76	72	66	59	40

Use P_E = 0.0 inches of rainfall as the target for ESD implementation

Hydrologic Soil Group 'B'											
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	61									
5%	63									
10%	65									
15%	67	**55**								
20%	68	60	**55**	**55**						
25%	70	64	61	58						
30%	72	65	62	59	**55**					
35%	74	66	63	60	56					
40%	75	66	63	60	56					
45%	78	68	66	62	58					
50%	80	70	67	64	60					
55%	81	71	68	65	61	**55**				
60%	83	73	70	67	63	58				
65%	85	75	72	69	65	60	**55**			
70%	87	77	74	71	67	62	57			
75%	89	79	76	73	69	65	59			
80%	91	81	78	75	71	66	61			
85%	92	82	79	76	72	67	62	**55**		
90%	94	84	81	78	74	70	65	59	**55**	
95%	96	87	84	81	77	73	69	63	57	
100%	98	89	86	83	80	76	72	66	59	**55**

Use P_E = 0.0 inches of rainfall as the target for ESD implementation

Hydrologic Soil Group 'C'											
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	74									
5%	75									
10%	76									
15%	78									
20%	79	**70**								
25%	80	72	**70**	**70**						
30%	81	73	72	71						
35%	82	74	73	72	**70**					
40%	84	77	75	73	71					
45%	85	78	76	74	71					
50%	86	78	76	74	71					
55%	86	78	76	74	71	**70**				
60%	88	80	78	76	73	71				
65%	90	82	80	77	75	72				
70%	91	82	80	78	75	72				
75%	92	83	81	79	75	72				
80%	93	84	82	79	76	72				
85%	94	85	82	79	76	72				
90%	95	86	83	80	77	73	**70**			
95%	97	88	85	82	79	75	71			
100%	98	89	86	83	80	76	72	**70**		

Use P_E = 1.8 inches of rainfall as the target for ESD implementation

Hydrologic Soil Group 'D'										
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	80									
5%	81									
10%	82									
15%	83									
20%	84	**77**								
25%	85	78								
30%	85	78	**77**	**77**						
35%	86	79	78	78						
40%	87	82	81	79	**77**					
45%	88	82	81	79	78					
50%	89	83	82	80	78					
55%	90	84	82	80	78					
60%	91	85	83	81	78					
65%	92	85	83	81	78					
70%	93	86	84	81	78					
75%	94	86	84	81	78					
80%	94	86	84	92	79					
85%	95	86	84	82	79					
90%	96	87	84	82	79	**77**				
95%	97	88	85	82	80	78				
100%	98	89	86	83	80	78	**77**			

Use P_E = 0.0 inches of rainfall as the target for ESD implementation

Compute Composite P_E:

HSG	Area	Target P_E		Net P_E
A	0.00 ac	0.0	0.00 ac x 0.00 / 0.40 ac =	0.0
B	0.00 ac	0.0	0.00 ac x 0.00 / 0.40 ac =	0.0
C	0.40 ac	1.8	0.40 ac x 1.80 / 0.40 ac =	1.8
D	0.00 ac	0.0	0.00 ac x 0.00 / 0.40 ac =	0.0
			Composite P_E =	**1.8**

C. Compute Q_E:

Q_E = Runoff depth used to size ESD practices

$Q_E = P_E * R_V$, where:

P_E = 1.8 in *(from above)*

$R_V = 0.05 + (0.009)(I)$; I = 41.10 %

$= 0.05 + 0.009 \times (41.10)$

$= 0.42$

Q_E = 1.8 " x 0.42

= **0.76 inches**

ESD Target for the Project

P_E = **1.8 Inches** *composite P_E, from above*

Q_E = **0.76 Inches**

D. Compute Target ESD_V & Re_V for Drainage Area 1:

Required Environmental Site Design Volume (ESD_V) for DA1:

$$ESD_V = [(P_E) \times (R_V) \times (DA)] / 12$$

where: Target P_E = 1.80 in. *(from Table 5.3, above)*

R_V = 0.42 *(from Q_E, above)*

DA = 17,269 sf or 0.40 ac *(from Site Tabulations, above)*

Target ESD_V = [(1.80 in.) x (0.42) x (17,269 sf)] / 12 =

= **1,088 cf**

Required Minimum Recharge Volume (Re_V) for DA1:

$$Re_V = [(S) \times (R_V) \times (DA)] / 12$$

Where:

Composite 'S' =

HSG	Area	Recharge Factor		Net 'S'
A	0.00 ac	0.38	0.00 ac x 0.38 / 0.40 ac	0.00
B	0.00 ac	0.26	0.00 ac x 0.26 / 0.40 ac	0.00
C	0.40 ac	0.13	0.40 ac x 0.13 / 0.40 ac	0.13
D	0.00 ac	0.07	0.00 ac x 0.07 / 0.40 ac	0.00
			Composite 'S' =	**0.13**

R_V = 0.42 *from WQ_V, above*

DA = 17,269 sf or 0.4 ac

Min. Re_V = [(0.13) x (0.42) x (17,269)] /12

= **79 cf**

E. Compute P_E Value & ESD_V or Project

DA-1a

ESD Practice N-1 Disconnection of Rooftop Runoff

Rooftop Surface	Roof Area	Soil Type	Disconnect Length	Average Slope	Weighted P_E Value
Lot 3 Roof	278 sf	C	15 ft.	2.0 %	0.20 in.
Lot 2 Roof A	121 sf	C	45 ft.	3.0 %	0.60 in.
Lot 2 Roof B	286 sf	C	30 ft.	3.0 %	0.40 in.
Lot 2 Roof C	259 sf	C	15 ft.	5.0 %	0.20 in.
Lot 2 Roof D	179 sf	C	30 ft.	3.0 %	0.40 in.
	sf	C	ft.	%	in.
	sf	C	ft.	%	in.
Totals:	**1,123 sf**				**0.30 in.**

ESD_V = [(P_E) x (R_V) x (A)]/ 12

where: P_E = 0.30 in. *(from above)*

R_V = 0.05 + (0.009 x %I)

= 0.05 + (0.009 x 100%)

= 0.95

A = 1,123 sf or 0.03 ac

ESD_V = (0.30 in. x 0.95 x 1,123 sf) / 12

= **27 cf**

Re_V = [(S) x (R_V) x (A)]/ 12

S = 0.13 *composite 'S' from above*

R_V = 0.05 + (0.009 x %I)

= 0.05 + (0.009 x 100%)

= 0.95

A = 1,123 sf or 0.03 ac

Re_V = [(0.13) x (0.95) x (1,123)] /12

= **12 cf**

DA-1b:

ESD Practice N-2 Disconnection of Non-Rooftop Runoff

Surface Description	Non-Rooftop	Soil HSG	Contributing Length	Disconnect Length	Average Slope	P_E Value
Lot 3 Stairs	29 sf	C	10 ft.	15 ft.	2.0 %	1.00 in.
Lot 2 Stairs	42 sf	C	10 ft.	11 ft.	3.0 %	1.00 in.
Lot 1 Stairs	42 sf	C	10 ft.	15 ft.	3.0 %	1.00 in.
	sf		ft.	ft.	%	0.00 in.
Totals:	**113 sf**					**1.00 in.**

ESD_V = [(P_E) x (R_V) x (A)]/ 12

where: P_E = 1.00 in. *(from chart above)*

R_V = 0.05 + (0.009 x %I)

= 0.05 + (0.009 x 100%)

= 0.95

A = 113 sf or 0.00 ac

ESD_V = [(1.00 in. x 0.95 x 113 sf)] / 12

= **9 cf**

Re_V = [(S) x (R_V) x (A)]/ 12

S = 0.13 *composite 'S' from above*

R_V = 0.05 + (0.009 x %I)

= 0.05 + (0.009 x 100%)

= 0.95

A = 113 sf or 0.00 ac

Re_V = [(0.13) x (0.95) x (113)] /12

= **1 cf**

DA-1c ESD Practice M-7 Rain Garden #1

Contributing Drainage Area = 1,741 sf or 0.04 Ac.

Impervious Surfaces in DA = 435 sf or 0.01 Ac.

%I = 435 sf / 1,741 sf = 25 %

Minimum Surface Area (A_f) = 2% of contributing DA

1,741 sf x 0.02 = 35 sf MINIMUM

Provided Surface Area (A_f) = 35 sf

A_f = 35 sf $\geq$ 35 sf **O.K.**

Concept Design Estimates:

where: P_E = 10 in x (A_f/DA) *(Eqn 5.1, MDE)*

= 10 in x (35 sf / 1,741 sf)

P_E = $\boxed{\textbf{0.20 in.}}$

R_V = 0.05 + (0.009 x %I)

= 0.05 + (0.009 x 25%)

= 0.28

ESD_V = (P_E x R_V x DA)/12

ESD_V = (0.20 in. x 0.28 x 1,741 sf) / 12

= $\boxed{\textbf{8 cf}}$ *(Concept Design Estimate)*

Re_V = [(S) x (R_V) x (DA)]/ 12

Where: R_V = 0.05 + (0.009 x %I)

= 0.05 + (0.009 x 25%)

= $\boxed{0.28}$

Re_V = [(0.13) x (0.28) x (1,741sf)] /12

= $\boxed{\textbf{5 cf}}$

Final Design Computations: ESD_V based on volume stored in device

Surface area = $\boxed{35 \text{ sf}}$ *(elev: 29.7)*

Filter Media Depth = 1.00 ft

Pea Gravel Depth = 0.33 ft *(4" #8 stone)*

Gravel Depth = 0.67 ft *(8" #57 stone)*

Total Media Depth = $\boxed{\textbf{2.00 ft}}$

Media Porosity = $\boxed{0.4}$

Media Storage Volume = 35sf x 2.00ft. x 0.4

= $\boxed{28 \text{ cf}}$

Ponding Depth = 0.50 ft

Side Slopes = 3:1

Max. Water Surface Area = 85 sf *(elev: 30.2)*

Ponding Storage Volume = [((85sf + 35sf) / 2) x 0.50ft.]

= $\boxed{30 \text{ cf}}$

ESD_V Storage provided = 28cf + 30cf

$\boxed{\textbf{58 cf}}$

P_E Provided = (ESD_V x 12)/(R_V x DA)

= (58cf x 12)/(0.28 x 1,741sf)

= $\boxed{\textbf{1.43 in.}}$

DA-1d ESD Practice M-6 Micro-Bioretention #1

Contributing Drainage Area = 4,026 sf or 0.09 Ac.
Impervious Surfaces in DA = 887 sf or 0.02 Ac.
%I = 887 sf / 4,026 sf = 22 %
Minimum Surface Area (A_f) = 2% of contributing DA
4,026 sf x 0.02 = 81 sf MINIMUM
Provided Surface Area (A_f) = 85 sf
A_f = 85 sf $\geq$ 81 sf **O.K.**

Concept Design Estimates:

where: P_E = 15 in x (A_f/DA) *(Eqn 5.2, MDE)*
= 15 in x (85 sf / 4,026 sf)
P_E = $\boxed{\textbf{0.32 in.}}$
R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 22%)
= 0.25
ESD_V = (P_E x R_V x DA)/12
ESD_V = (0.32 in. x 0.25 x 4,026 sf) / 12
= $\boxed{\textbf{27 cf}}$ *(Concept Design Estimate)*
Re_V = [(S) x (R_V) x (DA)]/ 12
Where: R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 22%)
= $\boxed{0.25}$
Re_V = [(0.13) x (0.25) x (4,026sf)] /12
= $\boxed{\textbf{11 cf}}$

Final Design Computations: ESD_V based on volume stored in device

Surface area = $\boxed{85 \text{ sf}}$ *(elev: 28.7)*
Filter Media Depth = 2.00 ft
Pea Gravel Depth = 0.50 ft *(6in. of #8 stone for Bridging Layer)*
Gravel Depth = 0.67 ft *(8in. of #57 stone for Gravel Jacket for underdrain)*
Total Media Depth = $\boxed{\textbf{3.17 ft}}$

Media Porosity = $\boxed{0.4}$
Media Storage Volume = 85sf x 3.17ft. x 0.4
= $\boxed{108 \text{ cf}}$

Ponding Depth = 0.50 ft
Side Slopes = 4:1
Max. Water Surface Area = 180 sf *(elev: 29.2)*
Ponding Storage Volume = [((180sf + 85sf) /2) x 0.50ft.]
= $\boxed{66 \text{ cf}}$
ESD_V Storage provided = 108cf + 66cf
$\boxed{\textbf{174 cf}}$
P_E Provided = (ESD_V x 12)/(R_V x DA)
= (174cf x 12)/(0.25 x 4,026sf)
= $\boxed{\textbf{2.07 in.}}$

DA-1e	ESD Practice M-5 Drywells											
	DA #	Roof Area	P_E	ESD_V	Drywell Storage (n = 0.4)						P_E Attained	HSG
	Lot10	722 sf	1.8 in.	103 cf	5.00	x	8.00	x	8.00	= 128 cf	2.13 in.	C
	Lot1	519 sf	1.8 in.	74 cf	5.00	x	7.00	x	7.00	= 98 cf	2.27 in.	C
		0 sf	1.8 in.	0 cf	0.00	x	0.00	x	0.00	= 0 cf	0.00 in.	C
		0 sf	0.0 in.	0 cf	0.00	x	0.00	x	0.00	= 0 cf	0.00 in.	C
	Totals:	**1,241 sf Rooftop Area**							**ESD_V =**	**226 cf**	**2.19 in. = P_E**	

DA-1f	ESD Practice M-6 Micro-Bioretention #2

Contributing Drainage Area = 11,500 sf or 0.26 Ac.

Impervious Surfaces in DA = 5,775 sf or 0.13 Ac.

%I = 5,775 sf / 11,500 sf = 50 %

Minimum Surface Area (A_f) = 2% of contributing DA

11,500 sf x 0.02 = 230 sf MINIMUM

Provided Surface Area (A_f) = 311 sf

A_f = 311 sf $\geq$ 230 sf **O.K.**

Concept Design Estimates:

where: P_E = 15 in x (A_f/DA) *(Eqn 5.2, MDE)*

= 15 in x (311 sf / 11,500 sf)

P_E = $\boxed{\textbf{0.41 in.}}$

R_V = 0.05 + (0.009 x %I)

= 0.05 + (0.009 x 50%)

= 0.50

ESD_V = (P_E x R_V x DA)/12

ESD_V = (0.41 in. x 0.50 x 11,500 sf) / 12

= $\boxed{\textbf{196 cf}}$ *(Concept Design Estimate)*

Re_V = [(S) x (R_V) x (DA)]/ 12

Where: R_V = 0.05 + (0.009 x %I)

= 0.05 + (0.009 x 50%)

= $\boxed{0.50}$

Re_V = [(0.13) x (0.50) x (11,500sf)] /12

= $\boxed{\textbf{62 cf}}$

Final Design Computations: ESD_V based on volume stored in device

Surface area = $\boxed{311 \text{ sf}}$ *(elev: 27.9)*

Filter Media Depth = 2.00 ft

Pea Gravel Depth = 0.50 ft *(6in. of #8 stone for Bridging Layer)*

Gravel Depth = 0.67 ft *(8in. of #57 stone for Gravel Jacket for underdrain)*

Total Media Depth = $\boxed{\textbf{3.17 ft}}$

Media Porosity = $\boxed{0.4}$

Media Storage Volume = 311sf x 3.17ft. x 0.4

= $\boxed{394 \text{ cf}}$

Ponding Depth = 0.50 ft

Side Slopes = 4:1

Max. Water Surface Area = 512 sf *(elev: 28.4)*

Ponding Storage Volume = [((512sf + 311sf) /2) x 0.50ft.]

= $\boxed{206 \text{ cf}}$

ESD_V Storage provided = 394cf + 206cf

$\boxed{\textbf{600 cf}}$

P_E Provided = (ESD_V x 12)/(R_V x DA)

= (600cf x 12)/(0.50 x 11,500sf)

= $\boxed{\textbf{1.25 in.}}$

P_E & ESD_V Summary:

Microscale & Non-Structural Practices							
DA #	ESD Practice	DA	ESD_V	Re_V	P_E Value	Weighted P_E Value	
1a	Disconnection of Rooftop Runoff	1,123 sf	27 cf	12 cf	0.30 in.	0.30" x 1,123 sf / 17,269 sf =	0.02 in.
1b	Disconnection of Non-Rooftop Runoff	113 sf	9 cf	1 cf	1.00 in.	1.00" x 113 sf / 17,269 sf =	0.01 in.
1c	Rain Garden #1	1,741 sf	58 cf	5 cf	1.43 in.	1.43" x 1,741 sf / 17,269 sf =	0.14 in.
1d	Micro-Bioretention #1	4,026 sf	174 cf	11 cf	2.07 in.	2.07" x 4,026 sf / 17,269 sf =	0.48 in.
1e	Drywells	1,241 sf	226 cf	226 cf	2.19 in.	2.19" x 1,241 sf / 17,269 sf =	0.16 in.
1f	Micro-Bioretention #2	11,500 sf	600 cf	62 cf	1.25 in.	1.25" x 11,500 sf / 17,269 sf =	0.83 in.
		Totals:	**1,094 cf**	**317 cf**		**Total Weighted P_E Value =**	**1.6 in.**
		Targets:	**1,088 cf**	**79 cf**		**Target P_E =**	**1.8 in.**
		ESD_V Provided:	**1,094 cf**				
		Additional Q_P Storage:	**0 cf**				
P_E Achieved = (12 x ESD_V)/(R_V x AREA) = (12 x 1,094c.f.) / (0.42 x 17,269sf) =							**1.8 in.**

III-b. Environmental Site Design – Drainage Area #2

Drainage Area #2 is the largest drainage area on the site. It contains a large portion of the proposed development, as well as pieces of off-site area. This area drains toward and outfalls at the south-eastern property corner. A variety of devices are proposed throughout this drainage area to manage runoff at the source. A submerged gravel wetlands is proposed at the outfall to provide qualitative management for the entire drainage area. This device has been undersized, with the understanding that the upstream micro-practices will provide pretreatment and manage a portion of the target volume from the contributing drainage area. The proposed storm drain system will collect over flow and convey it to the existing system in Bay Ridge Avenue.

Soils in this drainage area have a type "C" hydrologic classifications; the Target RCN for "woods in good condition" is 70. The proposed imperviousness for the development area is 49%. Utilizing Table 5.3 from the State Manual, a target rainfall depth (P_E) of 1.8" and a target runoff depth (Q_E) of 0.88" were determined. From these initial computations, a minimum Environmental Site Design Volume (ESD_V) of 6,608 c.f. of runoff would need to be managed, of which 479 c.f. would need to be Recharge Volume (Re_V).

ESD for this drainage area is achieved through the disconnection of rooftop and non-rooftop runoff, four micro-bioretention devices with enhanced filters, eight rain gardens with enhanced filters, and a submerged gravel wetlands. The ESD_V provided is 6,806 c.f., and the Re_V is 1,638 c.f. Both of these volumes are greater than the targets, and therefore, ESD is achieved to the MEP. The proposed development mimics "woods in good conditions" and satisfies channel protection obligations through the Reduced Runoff Curve Number Method.

Drum, Loyka, & Associates LLC

Designer: DE	Date: August 20, 2015	Checked By: WB	Date:
Title: Griscom Square			Job No.: BP12804
Subject: ESD Design			Sheet No. of

Site Data (Drainage Area 2):

Location: Tyler Avenue, Annapolis, MD							
Drainage Area (DA):		89,905 sf	or	2.06 Ac.			
Soils:	HSG 'A' =	0 sf	or	0 Ac.	or	0 %	of Site
	HSG 'B' =	0 sf	or	0 Ac.	or	0 %	of Site
	HSG 'C' =	89,905 sf	or	2.06 Ac.	or	100 %	of Site
	HSG 'D' =	0 sf	or	0 Ac.	or	0 %	of Site

Proposed On-site Impervious Surfaces =	38,499 sf	or	0.88 Ac.
Existing Off-site Impervious Surfaces =	5,676 sf	or	0.13 Ac.
Total Impervious Surfaces in DA =	44,175 sf	or	1.01 Ac.

Step 1: Determine ESD Implementation Goals

A. Determine Pre-Developed Conditions:

Soil Conditions and RCNs for "woods in good condition"

HSG	RCN*	Area	Percent
A	38	0.00 Ac.	0.00
B	55	0.00 Ac.	0.00
C	70	2.06 Ac.	100.00
D	77	0.00 Ac.	0.00

* RCN for "woods in good condition" *(Table 2-2, TR-55)*

** Actual RCN is less than 30, use RCN = 38

Composite RCN for "woods in good condition"

RCN_{woods} = [(38x0.00ac)+(55x0.00ac)+(70x2.06ac)+(77x0.00ac)] / 2.06ac

RCN_{woods} = 70

Target RCN for "woods in good condition" = $\boxed{70}$

B. Determine Target P_E Using Table 5.3

P_E = Rainfall used to size ESD practices

Proposed imperviousness (%I)

Proposed Impervious Area: 44,175 sf *from Site Data Table, above*

%I = Imp. Area / Drainage Area = 44,175sf / 89,905sf = 49.14 % = $\boxed{49\ \%}$

- Determine P_E from Table

21

Hydrologic Soil Group 'A'										
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	40									
5%	43									
10%	46									
15%	48	**38**								
20%	51	40	**38**	**38**						
25%	54	41	40	39						
30%	57	42	41	39	**38**					
35%	60	44	42	40	39					
40%	61	44	42	40	39					
45%	66	48	46	41	40					
50%	69	51	48	42	41	**38**				
55%	72	54	50	42	41	39				
60%	74	57	52	44	42	40	**38**			
65%	77	61	55	47	44	42	40			
70%	80	66	61	55	50	45	40			
75%	84	71	67	62	56	48	40	**38**		
80%	86	73	70	65	60	52	44	40		
85%	89	77	74	70	65	58	49	42	**38**	
90%	92	81	78	74	70	65	58	48	42	**38**
95%	95	85	82	78	75	70	65	57	50	39
100%	98	89	86	83	80	76	72	66	59	40

Use P_E = 0.0 inches of rainfall as the target for ESD implementation

Hydrologic Soil Group 'B'										
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	61									
5%	63									
10%	65									
15%	67	**55**								
20%	68	60	**55**	**55**						
25%	70	64	61	58						
30%	72	65	62	59	**55**					
35%	74	66	63	60	56					
40%	75	66	63	60	56					
45%	78	68	66	62	58					
50%	80	70	67	64	60					
55%	81	71	68	65	61	**55**				
60%	83	73	70	67	63	58				
65%	85	75	72	69	65	60	**55**			
70%	87	77	74	71	67	62	57			
75%	89	79	76	73	69	65	59			
80%	91	81	78	75	71	66	61			
85%	92	82	79	76	72	67	62	**55**		
90%	94	84	81	78	74	70	65	59	**55**	
95%	96	87	84	81	77	73	69	63	57	
100%	98	89	86	83	80	76	72	66	59	**55**

Use P_E = 0.0 inches of rainfall as the target for ESD implementation

Hydrologic Soil Group 'C'										
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	74									
5%	75									
10%	76									
15%	78									
20%	79	**70**								
25%	80	72	**70**	**70**						
30%	81	73	72	71						
35%	82	74	73	72	**70**					
40%	84	77	75	73	71					
45%	85	78	76	74	71					
50%	86	78	76	74	71					
55%	86	78	76	74	71	**70**				
60%	88	80	78	76	73	71				
65%	90	82	80	77	75	72				
70%	91	82	80	78	75	72				
75%	92	83	81	79	75	72				
80%	93	84	82	79	76	72				
85%	94	85	82	79	76	72				
90%	95	86	83	80	77	73	**70**			
95%	97	88	85	82	79	75	71			
100%	98	89	86	83	80	76	72	**70**		

Use P_E = 1.8 inches of rainfall as the target for ESD implementation

Hydrologic Soil Group 'D'										
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	80									
5%	81									
10%	82									
15%	83									
20%	84	**77**								
25%	85	78								
30%	85	78	**77**	**77**						
35%	86	79	78	78						
40%	87	82	81	79	**77**					
45%	88	82	81	79	78					
50%	89	83	82	80	78					
55%	90	84	82	80	78					
60%	91	85	83	81	78					
65%	92	85	83	81	78					
70%	93	86	84	81	78					
75%	94	86	84	81	78					
80%	94	86	84	92	79					
85%	95	86	84	82	79					
90%	96	87	84	82	79	**77**				
95%	97	88	85	82	80	78				
100%	98	89	86	83	80	78	**77**			

Use P_E = 0.0 inches of rainfall as the target for ESD implementation

Compute Composite P_E:

HSG	Area	Target P_E		Net P_E
A	0.00 ac	0.0	0.00 ac x 0.00 / 2.06 ac =	0.0
B	0.00 ac	0.0	0.00 ac x 0.00 / 2.06 ac =	0.0
C	2.06 ac	1.8	2.06 ac x 1.80 / 2.06 ac =	1.8
D	0.00 ac	0.0	0.00 ac x 0.00 / 2.06 ac =	0.0
			Composite P_E =	**1.8**

C. Compute Q_E:

Q_E = Runoff depth used to size ESD practices

$Q_E = P_E * R_V$, where:

P_E = 1.8 in *(from above)*

$R_V = 0.05 + (0.009)(I)$; I = 49.00 %

$= 0.05 + 0.009 \times (49.00)$

$= 0.49$

Q_E = 1.8 " x 0.49

= **0.88 inches**

ESD Target for the Project

P_E = **1.8 Inches** *composite P_E, from above*

Q_E = **0.88 Inches**

D. Compute Target ESD_V & Re_V for Drainage Area 2:

Required Environmental Site Design Volume (ESD_V) for DA2:

$ESD_V = [(P_E) \times (R_V) \times (DA)]/ 12$

where: Target P_E = 1.80 in. *(from Table 5.3, above)*

R_V = 0.49 *(from Q_E, above)*

DA = 89,905 sf or 2.06 ac *(from Site Tabulations, above)*

Target ESD_V = [(1.80 in.) x (0.49) x (89,905 sf)] / 12 =

= **6,608 cf**

Required Minimum Recharge Volume (Re_V) for Site:

$Re_V = [(S) \times (R_V) \times (DA)]/ 12$

Where:

Composite 'S' =

HSG	Area	Recharge Factor		Net 'S'
A	0.00 ac	0.38	0.00 ac x 0.38 / 2.06 ac	0.00
B	0.00 ac	0.26	0.00 ac x 0.26 / 2.06 ac	0.00
C	2.06 ac	0.13	2.06 ac x 0.13 / 2.06 ac	0.13
D	0.00 ac	0.07	0.00 ac x 0.07 / 2.06 ac	0.00
			Composite 'S' =	**0.13**

R_V = 0.49 *from WQ_V, above*

DA = 89,905 sf or 2.06 ac

Min. Re_V = [(0.13) x (0.49) x (89,905)] /12

= **479 cf**

E. Compute P_E Value & ESD_V or Project

DA-2a

ESD Practice N-1 Disconnection of Rooftop Runoff					
Rooftop	Roof Area	Soil Type	Disconnect	Average Slope	Weighted P_E
p/o Dwelling - Lot 3	129 sf	C	30 ft.	<5 %	0.40 in.
p/o Dwelling - Lot 2	121 sf	C	30 ft.	<5 %	0.40 in.
Offsite Roof - 1a	836 sf	C	45 ft.	<5 %	0.60 in.
Offsite Roof -1b	836 sf	C	30 ft.	<5 %	0.40 in.
Offsite Roof - 2a	834 sf	C	45 ft.	<5 %	0.60 in.
Offsite Roof - 2b	834 sf	C	60 ft.	<5 %	0.80 in.
Offsite Roof - 3	406 sf	C	45 ft.	<5 %	0.60 in.
	sf	C	ft.	%	in.
	sf	C	ft.	%	in.
Totals:	**3,996 sf**				**0.60 in.**

ESD_V = **$[(P_E) \times (R_V) \times (A)]/ 12$**

where: P_E = $\boxed{0.60\text{ in.}}$ *(from above)*

R_V = $0.05 + (0.009 \times \%I)$

= $0.05 + (0.009 \times 100\%)$

= $\boxed{0.95}$

A = $\boxed{3{,}996\text{ sf}}$ or 0.09 ac

ESD_V = (0.60 in. x 0.95 x 3,996 sf) / 12

= $\boxed{\textbf{190 cf}}$

Re_V = **$[(S) \times (R_V) \times (A)]/ 12$**

S = $\boxed{0.13}$ *composite 'S' from above*

R_V = $0.05 + (0.009 \times \%I)$

= $0.05 + (0.009 \times 100\%)$

= $\boxed{0.95}$

A = $\boxed{3{,}996\text{ sf}}$ or 0.09 ac

Re_V = [(0.13) x (0.95) x (3,996)] /12

= $\boxed{\textbf{41 cf}}$

DA-2b

ESD Practice N-2 Disconnection of Non-Rooftop Runoff						
Surface Description	Non-	Soil	Contributing	Disconnect	Average	P_E Value
Walk - Lot 3	43 sf	C	4 ft.	10 ft.	<5 %	1.00 in.
Walk - Lot 11	45 sf	C	4 ft.	10 ft.	<5 %	1.00 in.
Walk - Open Space	292 sf	C	5 ft.	10 ft.	<5 %	1.00 in.
	sf	C	ft.	ft.	<5 %	0.00 in.
	sf	C	ft.	ft.	<5 %	0.00 in.
Totals:	**380 sf**					**1.00 in.**

ESD_V = **$[(P_E) \times (R_V) \times (A)]/ 12$**

where: P_E = $\boxed{1.00\text{ in.}}$ *(from chart above)*

R_V = $0.05 + (0.009 \times \%I)$

= $0.05 + (0.009 \times 100\%)$

= $\boxed{0.95}$

A = $\boxed{380\text{ sf}}$ or 0.01 ac

ESD_V = **[(1.00 in. x 0.95 x 380 sf)] / 12**

= $\boxed{\textbf{30 cf}}$

Re_V = **$[(S) \times (R_V) \times (A)]/ 12$**

S = $\boxed{0.13}$ *composite 'S' from above*

R_V = $0.05 + (0.009 \times \%I)$

= $0.05 + (0.009 \times 100\%)$

= $\boxed{0.95}$

A = $\boxed{380\text{ sf}}$ or 0.01 ac

Re_V = **[(0.13 x 0.95 x 380 sf)] / 12**

= $\boxed{\textbf{4 cf}}$

DA-2c | ESD Practice M-6 Micro-Bioretention #3

Contributing Drainage Area = 7,406 sf or 0.17 Ac.
Impervious Surfaces in DA = 3,868 sf or 0.09 Ac.
%I = 3,868 sf / 7,406 sf = 52 %
Minimum Surface Area (A_f) = 2% of contributing DA
7,406 sf x 0.02 = 148 sf MINIMUM
Provided Surface Area (A_f) = 208 sf
A_f = 208 sf $\geq$ 148 sf **O.K.**

Concept Design Estimates:

where: P_E = 15 in x (A_f/DA) *(Eqn 5.2, MDE)*
= 15 in x (208 sf / 7,406 sf)
P_E = $\boxed{\textbf{0.42 in.}}$
R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 52%)
= 0.52
ESD_V = (P_E x R_V x DA)/12
ESD_V = (0.42 in. x 0.52 x 7,406 sf) / 12
= $\boxed{\textbf{135 cf}}$ *(Concept Design Estimate)*
Re_V = [(S) x (R_V) x (DA)]/ 12
Where: R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 52%)
= $\boxed{0.52}$
Re_V = [(0.13) x (0.52) x (7,406sf)] /12
= $\boxed{\textbf{42 cf}}$

Final Design Computations: ESD_V based on volume stored in device

Surface area = $\boxed{208 \text{ sf}}$ *(elev: 30.0)*
Filter Media Depth = 2.00 ft
Pea Gravel Depth = 0.50 ft *(6in. of #8 stone for Bridging Layer)*
Gravel Depth = 0.67 ft *(8in. of #57 stone for Gravel Jacket for underdrain)*
Total Media Depth = $\boxed{\textbf{3.17 ft}}$

Media Porosity = $\boxed{0.4}$
Media Storage Volume = 208sf x 3.17ft. x 0.4
= $\boxed{264 \text{ cf}}$

Ponding Depth = 0.50 ft
Side Slopes = 5:1
Max. Water Surface Area = 463 sf *(elev: 30.5)*
Ponding Storage Volume = [((463sf + 208sf) /2) x 0.50ft.]
= $\boxed{168 \text{ cf}}$
ESD_V Storage provided = 264cf + 168cf
$\boxed{\textbf{432 cf}}$
P_E Provided = (ESD_V x 12)/(R_V x DA)
= (432cf x 12)/(0.52 x 7,406sf)
= $\boxed{\textbf{1.35 in.}}$

DA-2c | ESD Practice M-9 Enhanced Filter

Filter Bed Area (A_f) = $\boxed{208 \text{ sf}}$ *(from above)*
Media Porsity (n) = $\boxed{0.4}$ *(#57 stone)*
Depth = $\boxed{3 \text{ ft.}}$ *(below invert of underdrain)*
ESD_V Provided = $\boxed{\textbf{250 cf}}$
P_E Provided = $\boxed{\textbf{0.78 in.}}$

DA-2d | ESD Practice M-6 Micro-Bioretention #4

Contributing Drainage Area = 5,851 sf or 0.13 Ac.
Impervious Surfaces in DA = 3,495 sf or 0.08 Ac.
%I = 3,495 sf / 5,851 sf = 60 %
Minimum Surface Area (A_f) = 2% of contributing DA
5,851 sf x 0.02 = 117 sf MINIMUM
Provided Surface Area (A_f) = 154 sf
A_f = 154 sf $\geq$ 117 sf **O.K.**

Concept Design Estimates:

where: P_E = 15 in x (A_f/DA) *(Eqn 5.2, MDE)*
= 15 in x (154 sf / 5,851 sf)
P_E = $\boxed{0.39 \text{ in.}}$
R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 60%)
= 0.59
ESD_V = (P_E x R_V x DA)/12
ESD_V = (0.39 in. x 0.59 x 5,851 sf) / 12
= $\boxed{112 \text{ cf}}$ *(Concept Design Estimate)*
Re_V = [(S) x (R_V) x (DA)]/ 12
Where: R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 60%)
= $\boxed{0.59}$
Re_V = [(0.13) x (0.59) x (5,851sf)] /12
= $\boxed{37 \text{ cf}}$

Final Design Computations: ESD_V based on volume stored in device

Surface area = $\boxed{154 \text{ sf}}$ *(elev: 30.0)*
Filter Media Depth = 1.83 ft
Pea Gravel Depth = 0.33 ft *(4in. of #8 stone for Bridging Layer)*
Gravel Depth = 0.67 ft *(8in. of #57 stone for Gravel Jacket for underdrain)*
Total Media Depth = $\boxed{2.83 \text{ ft}}$
Media Porosity = $\boxed{0.4}$
Media Storage Volume = 154sf x 2.83ft. x 0.4
= $\boxed{174 \text{ cf}}$
Ponding Depth = 0.50 ft
Side Slopes = 5:1
Max. Water Surface Area = 326 sf *(elev: 30.5)*
Ponding Storage Volume = [((326sf + 154sf) / 2) x 0.50ft.]
= $\boxed{120 \text{ cf}}$
ESD_V Storage provided = 174cf + 120cf
$\boxed{294 \text{ cf}}$
P_E Provided = (ESD_V x 12)/(R_V x DA)
= (294cf x 12)/(0.59 x 5,851sf)
= $\boxed{1.02 \text{ in.}}$

DA-2d | ESD Practice M-9 Enhanced Filter

Filter Bed Area (A_f) = $\boxed{154 \text{ sf}}$ *(from above)*
Media Porsity (n) = $\boxed{0.4}$ *(#57 stone)*
Depth = $\boxed{3.25 \text{ ft.}}$ *(below invert of underdrain)*
ESD_V Provided = $\boxed{200 \text{ cf}}$
P_E Provided = $\boxed{0.7 \text{ in.}}$

DA-2e	ESD Practice M-6 Micro-Bioretention #5

Contributing Drainage Area = 6,067 sf or 0.14 Ac.
Impervious Surfaces in DA = 2,441 sf or 0.06 Ac.
%I = 2,441 sf / 6,067 sf = 40 %
Minimum Surface Area (A_f) = 2% of contributing DA
6,067 sf x 0.02 = 121 sf MINIMUM
Provided Surface Area (A_f) = 123 sf
A_f = 123 sf $\geq$ 121 sf **O.K.**

Concept Design Estimates:

where: P_E = 15 in x (A_f/DA) *(Eqn 5.2, MDE)*
= 15 in x (123 sf / 6,067 sf)
P_E = $\boxed{\textbf{0.30 in.}}$
R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 40%)
= 0.41
ESD_V = (P_E x R_V x DA)/12
ESD_V = (0.30 in. x 0.41 x 6,067 sf) / 12
= $\boxed{\textbf{62 cf}}$ *(Concept Design Estimate)*
Re_V = [(S) x (R_V) x (DA)]/ 12
Where: R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 40%)
= $\boxed{0.41}$
Re_V = [(0.13) x (0.41) x (6,067sf)] /12
= $\boxed{\textbf{27 cf}}$

Final Design Computations: ESD_V based on volume stored in device

Surface area = $\boxed{123 \text{ sf}}$ *(elev: 31.6)*
Filter Media Depth = 2.00 ft
Pea Gravel Depth = 0.50 ft *(6in. of #8 stone for Bridging Layer)*
Gravel Depth = 0.67 ft *(8in. of #57 stone for Gravel Jacket for underdrain)*
Total Media Depth = $\boxed{\textbf{3.17 ft}}$
Media Porosity = $\boxed{0.4}$
Media Storage Volume = 123sf x 3.17ft. x 0.4
= $\boxed{156 \text{ cf}}$
Ponding Depth = 0.50 ft
Side Slopes = 5:1
Max. Water Surface Area = 193 sf *(elev: 32.1)*
Ponding Storage Volume = [(193sf + 123sf /2) x 0.50ft.]
= $\boxed{79 \text{ cf}}$
ESD_V Storage provided = 156cf + 79cf
$\boxed{\textbf{235 cf}}$
P_E Provided = (ESD_V x 12)/(R_V x DA)
= (235cf x 12)/(0.41 x 6,067sf)
= $\boxed{\textbf{1.13 in.}}$

DA-2e	ESD Practice M-9 Enhanced Filter

Filter Bed Area (A_f) = $\boxed{123 \text{ sf}}$ *(from above)*
Media Porsity (n) = $\boxed{0.4}$ *(#57 stone)*
Depth = $\boxed{3 \text{ ft.}}$ *(below invert of underdrain)*
ESD_V Provided = $\boxed{\textbf{148 cf}}$
P_E Provided = $\boxed{\textbf{0.71 in.}}$

DA-2f ESD Practice M-6 Micro-Bioretention #6

Contributing Drainage Area = 3,602 sf or 0.08 Ac.
Impervious Surfaces in DA = 1,460 sf or 0.03 Ac.
%I = 1,460 sf / 3,602 sf = 41 %
Minimum Surface Area (A_f) = 2% of contributing DA
3,602 sf x 0.02 = 72 sf MINIMUM
Provided Surface Area (A_f) = 87 sf
A_f = 87 sf $\geq$ 72 sf **O.K.**

Concept Design Estimates:

where: P_E = 15 in x (A_f/DA) *(Eqn 5.2, MDE)*
= 15 in x (87 sf / 3,602 sf)
P_E = **0.36 in.**
R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 41%)
= 0.42
ESD_V = (P_E x R_V x DA)/12
ESD_V = (0.36 in. x 0.42 x 3,602 sf) / 12
= **45 cf** *(Concept Design Estimate)*
Re_V = [(S) x (R_V) x (DA)]/ 12
Where: R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 41%)
= 0.42
Re_V = [(0.13) x (0.42) x (3,602sf)] /12
= **16 cf**

Final Design Computations: ESD_V based on volume stored in device

Surface area = 87 sf *(elev: 31.8)*
Filter Media Depth = 2.00 ft
Pea Gravel Depth = 0.50 ft *(6in. of #8 stone for Bridging Layer)*
Gravel Depth = 0.67 ft *(8in. of #57 stone for Gravel Jacket for underdrain)*
Total Media Depth = 3.17 ft
Media Porosity = 0.4
Media Storage Volume = 87sf x 3.17ft. x 0.4
= 110 cf

Ponding Depth = 0.50 ft
Side Slopes = 5:1
Max. Water Surface Area = 148 sf *(elev: 32.3)*
Ponding Storage Volume = [(148sf + 87sf /2) x 0.50ft.]
= 59 cf
ESD_V Storage provided = 110cf + 59cf
169 cf
P_E Provided = (ESD_V x 12)/(R_V x DA)
= (169cf x 12)/(0.42 x 3,602sf)
= **1.34 in.**

DA-2f ESD Practice M-9 Enhanced Filter

Filter Bed Area (A_f) = 87 sf *(from above)*
Media Porsity (n) = 0.4 *(#57 stone)*
Depth = 3 ft. *(below invert of underdrain)*
ESD_V Provided = 104 cf
P_E Provided = 0.82 in.

DA-2g | ESD Practice M-7 Rain Garden #2

Contributing Drainage Area = 1,150 sf or 0.03 Ac.
Impervious Surfaces in DA = 627 sf or 0.01 Ac.
%I = 627 sf / 1,150 sf = 55 %
Minimum Surface Area (A_f) = 2% of contributing DA
1,150 sf x 0.02 = 23 sf MINIMUM
Provided Surface Area (A_f) = 65 sf
A_f = 65 sf $\geq$ 23 sf **O.K.**

Concept Design Estimates:

where: P_E = 10 in x (A_f/DA) *(Eqn 5.1, MDE)*
= 10 in x (65 sf / 1,150 sf)
P_E = $\boxed{\textbf{0.57 in.}}$
R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 55%)
= 0.55

ESD_V = (P_E x R_V x DA)/12
ESD_V = (0.57 in. x 0.55 x 1,150 sf) / 12
= $\boxed{\textbf{30 cf}}$ *(Concept Design Estimate)*

Re_V = [(S) x (R_V) x (DA)]/ 12
Where: R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 55%)
= $\boxed{0.55}$
Re_V = [(0.13) x (0.55) x (1,150sf)] /12
= $\boxed{\textbf{7 cf}}$

Final Design Computations: ESD_V based on volume stored in device

Surface area = $\boxed{65 \text{ sf}}$ *(elev: 29.0)*
Filter Media Depth = 1.00 ft
Pea Gravel Depth = 0.33 ft *(4" #8 stone)*
Gravel Depth = 0.67 ft *(8" #57 stone)*
Total Media Depth = $\boxed{\textbf{2.00 ft}}$
Media Porosity = $\boxed{0.4}$
Media Storage Volume = 65sf x 2.00ft. x 0.4
= $\boxed{52 \text{ cf}}$
Ponding Depth = 0.50 ft
Side Slopes = 3:1
Max. Water Surface Area = 130 sf *(elev: 29.5)*
Ponding Storage Volume = [((130sf + 65sf) / 2) x 0.50ft.]
= $\boxed{49 \text{ cf}}$
ESD_V Storage provided = 52cf + 49cf
$\boxed{\textbf{101 cf}}$
P_E Provided = (ESD_V x 12)/(R_V x DA)
= (101cf x 12)/(0.55 x 1,150sf)
= $\boxed{\textbf{1.92 in.}}$

DA-2g | ESD Practice M-9 Enhanced Filter

Filter Bed Area (A_f) = $\boxed{65 \text{ sf}}$ *(from above)*
Media Porsity (n) = $\boxed{0.4}$ *(#57 stone)*
Depth = $\boxed{1.5 \text{ ft.}}$ *(below invert of underdrain)*
ESD_V Provided = $\boxed{\textbf{39 cf}}$
P_E Provided = $\boxed{\textbf{0.74 in.}}$

DA-2h | ESD Practice M-7 Rain Garden #3

Contributing Drainage Area = 1,744 sf or 0.04 Ac.
Impervious Surfaces in DA = 836 sf or 0.02 Ac.
%I = 836 sf / 1,744 sf = 48 %
Minimum Surface Area (A_f) = 2% of contributing DA
1,744 sf x 0.02 = 35 sf MINIMUM
Provided Surface Area (A_f) = 66 sf
A_f = 66 sf $\geq$ 35 sf **O.K.**

Concept Design Estimates:

where: P_E = 10 in x (A_f/DA) *(Eqn 5.1, MDE)*
= 10 in x (66 sf / 1,744 sf)
P_E = 0.38 in.
R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 48%)
= 0.48

ESD_V = (P_E x R_V x DA)/12
ESD_V = (0.38 in. x 0.48 x 1,744 sf) / 12
= **27 cf** *(Concept Design Estimate)*

Re_V = [(S) x (R_V) x (DA)]/ 12
Where: R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 48%)
= 0.48
Re_V = [(0.13) x (0.48) x (1,744sf)] /12
= **9 cf**

Final Design Computations: ESD_V based on volume stored in device

Surface area = 66 sf *(elev: 29.5)*
Filter Media Depth = 1.00 ft
Pea Gravel Depth = 0.33 ft *(4" #8 stone)*
Gravel Depth = 0.67 ft *(8" #57 stone)*
Total Media Depth = 2.00 ft
Media Porosity = 0.4
Media Storage Volume = 66sf x 2.00ft. x 0.4
= 53 cf
Ponding Depth = 0.50 ft
Side Slopes = 3:1
Max. Water Surface Area = 121 sf *(elev: 30.0)*
Ponding Storage Volume = [((121sf + 66sf) / 2) x 0.50ft.]
= 47 cf
ESD_V Storage provided = 53cf + 47cf
100 cf
P_E Provided = (ESD_V x 12)/(R_V x DA)
= (100cf x 12)/(0.48 x 1,744sf)
= **1.43 in.**

DA-2h | ESD Practice M-9 Enhanced Filter

Filter Bed Area (A_f) = 66 sf *(from above)*
Media Porsity (n) = 0.4 *(#57 stone)*
Depth = 2.5 ft. *(below invert of underdrain)*
ESD_V Provided = 66 cf
P_E Provided = 0.95 in.

DA-2i | ESD Practice M-7 Rain Garden #4

Contributing Drainage Area = 860 sf or 0.02 Ac.
Impervious Surfaces in DA = 269 sf or 0.01 Ac.
%I = 269 sf / 860 sf = 31 %
Minimum Surface Area (A_f) = 2% of contributing DA
860 sf x 0.02 = 17 sf MINIMUM
Provided Surface Area (A_f) = 35 sf
A_f = 35 sf $\geq$ 17 sf **O.K.**

Concept Design Estimates:

where: P_E = 10 in x (A_f/DA) *(Eqn 5.1, MDE)*
= 10 in x (35 sf / 860 sf)
P_E = $\boxed{\textbf{0.41 in.}}$
R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 31%)
= 0.33

ESD_V = (P_E x R_V x DA)/12
ESD_V = (0.41 in. x 0.33 x 860 sf) / 12
= $\boxed{\textbf{10 cf}}$ *(Concept Design Estimate)*

Re_V = [(S) x (R_V) x (DA)]/ 12
Where: R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 31%)
= $\boxed{0.33}$
Re_V = [(0.13) x (0.33) x (860sf)] /12
= $\boxed{\textbf{3 cf}}$

Final Design Computations: ESD_V based on volume stored in device

Surface area = $\boxed{35 \text{ sf}}$ *(elev: 32.7)*
Filter Media Depth = 1.00 ft
Pea Gravel Depth = 0.33 ft *(4" #8 stone)*
Gravel Depth = 0.67 ft *(8" #57 stone)*
Total Media Depth = $\boxed{\textbf{2.00 ft}}$

Media Porosity = $\boxed{0.4}$
Media Storage Volume = 35sf x 2.00ft. x 0.4
= $\boxed{28 \text{ cf}}$
Ponding Depth = 0.30 ft
Side Slopes = 5:1
Max. Water Surface Area = 79 sf *(elev: 33.0)*
Ponding Storage Volume = [((79sf + 35sf) / 2) x 0.30ft.]
= $\boxed{17 \text{ cf}}$
ESD_V Storage provided = 28cf + 17cf
$\boxed{\textbf{45 cf}}$
P_E Provided = (ESD_V x 12)/(R_V x DA)
= (45cf x 12)/(0.33 x 860sf)
= $\boxed{\textbf{1.90 in.}}$

DA-2i | ESD Practice M-9 Enhanced Filter

Filter Bed Area (A_f) = $\boxed{35 \text{ sf}}$ *(from above)*
Media Porsity (n) = $\boxed{0.4}$ *(#57 stone)*
Depth = $\boxed{1 \text{ ft.}}$ *(below invert of underdrain)*
ESD_V Provided = $\boxed{\textbf{14 cf}}$
P_E Provided = $\boxed{\textbf{0.59 in.}}$

DA-2j ESD Practice M-7 Rain Garden #5

Contributing Drainage Area	=	1,042 sf or	0.02 Ac.
Impervious Surfaces in DA	=	526 sf or	0.01 Ac.
%I = 526 sf / 1,042 sf	=	50 %	
Minimum Surface Area (A_f)	=	2% of contributing DA	
1,042 sf x 0.02	=	21 sf MINIMUM	
Provided Surface Area (A_f)	=	**36 sf**	

A_f = 36 sf $\geq$ 21 sf **O.K.**

Concept Design Estimates:

where: P_E = 10 in x (A_f/DA) *(Eqn 5.1, MDE)*

= 10 in x (36 sf / 1,042 sf)

P_E = $\boxed{\textbf{0.35 in.}}$

R_V = 0.05 + (0.009 x %I)

= 0.05 + (0.009 x 50%)

= 0.5

ESD_V = (P_E x R_V x DA)/12

ESD_V = (0.35 in. x 0.50 x 1,042 sf) / 12

= $\boxed{\textbf{15 cf}}$ *(Concept Design Estimate)*

Re_V = [(S) x (R_V) x (DA)]/ 12

Where: R_V = 0.05 + (0.009 x %I)

= 0.05 + (0.009 x 50%)

= $\boxed{0.5}$

Re_V = [(0.13) x (0.50) x (1,042sf)] /12

= $\boxed{\textbf{6 cf}}$

Final Design Computations: ESD_V based on volume stored in device

Surface area	=	36 sf	*(elev: 33.3)*
Filter Media Depth	=	1.00 ft	
Pea Gravel Depth	=	0.33 ft	*(4" #8 stone)*
Gravel Depth	=	0.67 ft	*(8" #57 stone)*
Total Media Depth	=	**2.00 ft**	
Media Porosity	=	0.4	
Media Storage Volume	=	36sf x 2.00ft. x 0.4	
	=	29 cf	
Ponding Depth	=	0.50 ft	
Side Slopes	=	3:1	
Max. Water Surface Area	=	78 sf	*(elev: 33.8)*
Ponding Storage Volume	=	[((78sf + 36sf) / 2) x 0.50ft.]	
	=	29 cf	
ESD_V Storage provided	=	29cf + 29cf	
		58 cf	
P_E Provided	=	**(ESD_V x 12)/(R_V x DA)**	
	=	(58cf x 12)/(0.50 x 1,042sf)	
	=	**1.34 in.**	

DA-2j ESD Practice M-9 Enhanced Filter

Filter Bed Area (A_f)	=	36 sf	*(from above)*
Media Porsity (n)	=	0.4	*(#57 stone)*
Depth	=	2.5 ft.	*(below invert of underdrain)*
ESD_V Provided	=	**36 cf**	
P_E Provided	=	**0.83 in.**	

DA-2k — ESD Practice M-7 Rain Garden #6

Contributing Drainage Area = 1,029 sf or 0.02 Ac.
Impervious Surfaces in DA = 353 sf or 0.01 Ac.
%I = 353 sf / 1,029 sf = 34 %
Minimum Surface Area (A_f) = 2% of contributing DA
1,029 sf x 0.02 = 21 sf MINIMUM
Provided Surface Area (A_f) = 45 sf
A_f = 45 sf ≥ 21 sf **O.K.**

Concept Design Estimates:

where: P_E = 10 in x (A_f/DA) *(Eqn 5.1, MDE)*
= 10 in x (45 sf / 1,029 sf)
P_E = 0.44 in.
R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 34%)
= 0.36

ESD_V = (P_E x R_V x DA)/12
ESD_V = (0.44 in. x 0.36 x 1,029 sf) / 12
= **14 cf** *(Concept Design Estimate)*

Re_V = [(S) x (R_V) x (DA)]/ 12
Where: R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 34%)
= 0.36
Re_V = [(0.13) x (0.36) x (1,029sf)] /12
= **4 cf**

Final Design Computations: ESD_V based on volume stored in device

Surface area = 45 sf *(elev: 31.5)*
Filter Media Depth = 1.00 ft
Pea Gravel Depth = 0.33 ft *(4" #8 stone)*
Gravel Depth = 0.67 ft *(8" #57 stone)*
Total Media Depth = 2.00 ft
Media Porosity = 0.4
Media Storage Volume = 45sf x 2.00ft. x 0.4
= 36 cf
Ponding Depth = 0.50 ft
Side Slopes = 3:1
Max. Water Surface Area = 98 sf *(elev: 32.0)*
Ponding Storage Volume = [((98sf + 45sf) / 2) x 0.50ft.]
= 36 cf
ESD_V Storage provided = 36cf + 36cf
72 cf
P_E Provided = (ESD_V x 12)/(R_V x DA)
= (72cf x 12)/(0.36 x 1,029sf)
= **2.33 in.**

DA-2k — ESD Practice M-9 Enhanced Filter

Filter Bed Area (A_f) = 45 sf *(from above)*
Media Porsity (n) = 0.4 *(#57 stone)*
Depth = 0.5 ft. *(below invert of underdrain)*
ESD_V Provided = 9 cf
P_E Provided = 0.29 in.

DA-2I | ESD Practice M-7 Rain Garden #7

Contributing Drainage Area = 1,625 sf or 0.04 Ac.
Impervious Surfaces in DA = 870 sf or 0.02 Ac.
%I = 870 sf / 1,625 sf = 54 %
Minimum Surface Area (A_f) = 2% of contributing DA
1,625 sf x 0.02 = 33 sf MINIMUM
Provided Surface Area (A_f) = 57 sf
A_f = 57 sf $\geq$ 33 sf **O.K.**

Concept Design Estimates:

where: P_E = 10 in x (A_f/DA) *(Eqn 5.1, MDE)*
= 10 in x (57 sf / 1,625 sf)
P_E = $\boxed{\textbf{0.35 in.}}$
R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 54%)
= 0.54

ESD_V = (P_E x R_V x DA)/12
ESD_V = (0.35 in. x 0.54 x 1,625 sf) / 12
= $\boxed{\textbf{26 cf}}$ *(Concept Design Estimate)*

Re_V = [(S) x (R_V) x (DA)]/ 12
Where: R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 54%)
= $\boxed{0.54}$
Re_V = [(0.13) x (0.54) x (1,625sf)] /12
= $\boxed{\textbf{10 cf}}$

Final Design Computations: ESD_V based on volume stored in device

Surface area = $\boxed{57 \text{ sf}}$ *(elev: 28.9)*
Filter Media Depth = 1.00 ft
Pea Gravel Depth = 0.33 ft *(4" #8 stone)*
Gravel Depth = 0.67 ft *(8" #57 stone)*
Total Media Depth = $\boxed{\textbf{2.00 ft}}$
Media Porosity = $\boxed{0.4}$
Media Storage Volume = 57sf x 2.00ft. x 0.4
= $\boxed{46 \text{ cf}}$
Ponding Depth = 0.50 ft
Side Slopes = 3:1
Max. Water Surface Area = 116 sf *(elev: 29.4)*
Ponding Storage Volume = [((116sf + 57sf) / 2) x 0.50ft.]
= $\boxed{43 \text{ cf}}$
ESD_V Storage provided = 46cf + 43cf
$\boxed{\textbf{89 cf}}$
P_E Provided = **(ESD_V x 12)/(R_V x DA)**
= (89cf x 12)/(0.54 x 1,625sf)
= $\boxed{\textbf{1.22 in.}}$

DA-2I | ESD Practice M-9 Enhanced Filter

Filter Bed Area (A_f) = $\boxed{57 \text{ sf}}$ *(from above)*
Media Porsity (n) = $\boxed{0.4}$ *(#57 stone)*
Depth = $\boxed{2 \text{ ft.}}$ *(below invert of underdrain)*
ESD_V Provided = $\boxed{\textbf{46 cf}}$
P_E Provided = $\boxed{\textbf{0.63 in.}}$

DA-2m | ESD Practice M-7 Rain Garden #8

Contributing Drainage Area = 885 sf or 0.02 Ac.
Impervious Surfaces in DA = 474 sf or 0.01 Ac.
%I = 474 sf / 885 sf = 54 %
Minimum Surface Area (A_f) = 2% of contributing DA
885 sf x 0.02 = 18 sf MINIMUM
Provided Surface Area (A_f) = 28 sf
A_f = 28 sf $\geq$ 18 sf **O.K.**

Concept Design Estimates:

where: P_E = 10 in x (A_f/DA) *(Eqn 5.1, MDE)*
= 10 in x (28 sf / 885 sf)
P_E = $\boxed{0.32 \text{ in.}}$
R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 54%)
= 0.54

ESD_V = (P_E x R_V x DA)/12
ESD_V = (0.32 in. x 0.54 x 885 sf) / 12
= **$\boxed{13 \text{ cf}}$** *(Concept Design Estimate)*

Re_V = [(S) x (R_V) x (DA)]/ 12
Where: R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 54%)
= $\boxed{0.54}$
Re_V = [(0.13) x (0.54) x (885sf)] /12
= **$\boxed{5 \text{ cf}}$**

Final Design Computations: ESD_V based on volume stored in device

Surface area = $\boxed{28 \text{ sf}}$ *(elev: 28.9)*
Filter Media Depth = 1.00 ft
Pea Gravel Depth = 0.33 ft *(4" #8 stone)*
Gravel Depth = 0.67 ft *(8" #57 stone)*
Total Media Depth = $\boxed{2.00 \text{ ft}}$
Media Porosity = $\boxed{0.4}$
Media Storage Volume = 28sf x 2.00ft. x 0.4
= $\boxed{22 \text{ cf}}$
Ponding Depth = 0.50 ft
Side Slopes = 3:1
Max. Water Surface Area = 74 sf *(elev: 29.4)*
Ponding Storage Volume = [((74sf + 28sf) / 2) x 0.50ft.]
= $\boxed{26 \text{ cf}}$
ESD_V Storage provided = 22cf + 26cf
$\boxed{48 \text{ cf}}$
P_E Provided = (ESD_V x 12)/(R_V x DA)
= (48cf x 12)/(0.54 x 885sf)
= **$\boxed{1.21 \text{ in.}}$**

DA-2m | ESD Practice M-9 Enhanced Filter

Filter Bed Area (A_f) = $\boxed{28 \text{ sf}}$ *(from above)*
Media Porsity (n) = $\boxed{0.4}$ *(#57 stone)*
Depth = $\boxed{2 \text{ ft.}}$ *(below invert of underdrain)*
ESD_V Provided = $\boxed{22 \text{ cf}}$
P_E Provided = $\boxed{0.55 \text{ in.}}$

DA-2n	ESD Practice M-7 Rain Garden #9				
	Contributing Drainage Area	=	690 sf or	0.02 Ac.	
	Impervious Surfaces in DA	=	308 sf or	0.01 Ac.	
	%I = 308 sf / 690 sf	=	45 %		
	Minimum Surface Area (A_f)	=	2% of contributing DA		
	690 sf x 0.02	=	14 sf MINIMUM		
	Provided Surface Area (A_f)	=	**23 sf**		
	A_f =		23 sf $\geq$	14 sf	**O.K.**

Concept Design Estimates:

where: P_E = 10 in x (A_f/DA) *(Eqn 5.1, MDE)*

= 10 in x (23 sf / 690 sf)

P_E = $\boxed{\textbf{0.33 in.}}$

R_V = 0.05 + (0.009 x %I)

= 0.05 + (0.009 x 45%)

= 0.46

ESD_V = (P_E x R_V x DA)/12

ESD_V = (0.33 in. x 0.46 x 690 sf) / 12

= $\boxed{\textbf{9 cf}}$ *(Concept Design Estimate)*

Re_V = [(S) x (R_V) x (DA)]/ 12

Where: R_V = 0.05 + (0.009 x %I)

= 0.05 + (0.009 x 45%)

= $\boxed{0.46}$

Re_V = [(0.13) x (0.46) x (690sf)] /12

= $\boxed{\textbf{3 cf}}$

Final Design Computations: ESD_V based on volume stored in device

Surface area	=	23 sf	*(elev: 30.2)*
Filter Media Depth	=	1.00 ft	
Pea Gravel Depth	=	0.33 ft	*(4" #8 stone)*
Gravel Depth	=	0.67 ft	*(8" #57 stone)*
Total Media Depth	=	**2.00 ft**	
Media Porosity	=	0.4	
Media Storage Volume	=	23sf x 2.00ft. x 0.4	
	=	18 cf	
Ponding Depth	=	0.50 ft	
Side Slopes	=	3:1	
Max. Water Surface Area	=	70 sf	*(elev: 30.7)*
Ponding Storage Volume	=	[((70sf + 23sf) / 2) x 0.50ft.]	
	=	23 cf	
ESD_V Storage provided	=	18cf + 23cf	
		41 cf	
P_E Provided	=	**(ESD_V x 12)/(R_V x DA)**	
	=	(41cf x 12)/(0.46 x 690sf)	
	=	**1.55 in.**	

DA-2n	ESD Practice M-9 Enhanced Filter		
	Filter Bed Area (A_f) =	23 sf	*(from above)*
	Media Porsity (n) =	0.4	*(#57 stone)*
	Depth =	2 ft.	*(below invert of underdrain)*
	ESD_V Provided =	**18 cf**	
	P_E Provided =	**0.68 in.**	

DA-2o | ESD Practice M-2 Submerged Gravel Wetland #1

Contributing Drainage Area = 89,905 sf or 2.06 Ac.

Impervious Surfaces in DA = 44,175 sf or 1.01 Ac.

%I = 44,175 sf / 89,905 sf = 49 %

ESD_V: Runoff volume managed by ESD practice

Target ESD_V = [(P_E) x (R_V) x (DA)]/12

Target P_E = $\boxed{1.80 \text{ in.}}$

R_V = 0.05 + (0.009 x %I)

= 0.05 + (0.009 x 49%)

= 0.49

= [(1.80in.) x (0.49) x (89,905sf)] / 12 = $\boxed{6,608 \text{ cf}}$

Re_V = [(S) x (R_V) x (DA)]/ 12

= [(0.13) x (0.49) x (89,905sf)] /12 = $\boxed{477 \text{ cf}}$

Submerged Gravel Wetland Design:

This device is the downstream device for this drainage area. The 4 micro-bio devices and the 9 rain gardens within this drainage area are upstream of this submerged gravel wetland, and provide pretreatment for at least 10% of the total ESDv.

ESDv provided by upstream Micro-bioretention devices:		1,832 cf
ESDv provided by upstream Rain Gardens:		804 cf
Total ESDv provided by upstream devices:		2,636 cf
Required pretreatment volume, 10% of	6,608 cf:	661 cf

Gravel Wetland Design:

Planting Media	=	2.5 ft	top elev: 22.0'
Pea Gravel Bridge	=	0.5 ft	top elev: 21.0'
Gravel substrate depth	=	2.0 ft	top elev: 21.5'
			bottom elev: 19.5'

SGW ESD Ponding Volume:

Wetland Surface area	=	1467 sf	*(El 22.0)*
Ponding Depth	=	2.00 ft	
Side Slopes	=	3:1	
Max. Water Surface Area	=	2,483 sf	*(El 24.0)*

Ponding Storage Volume = [((2,483sf + 1,467sf) / 2) x 2.00ft.]

= $\boxed{3,950 \text{ cf}}$

P_E Provided = $\boxed{1.1 \text{ in.}}$ *(based on storage volume)*

P_E & ESD_V Summary:

Microscale & Non-Structural Practices						
DA #	ESD Practice	DA	ESD_V	Re_V	P_E Value	Weighted P_E Value
2a	Disconnection of Rooftop Runoff	3,996 sf	190 cf	41 cf	0.60 in.	0.60" x 3,996 sf / 89,905 sf = 0.03 in.
2b	Disconnection of Non-Rooftop Runoff	380 sf	30 cf	4 cf	1.00 in.	1.00" x 380 sf / 89,905 sf = 0.00 in.
2c	Micro-Bioretention #3	7,406 sf	432 cf	42 cf	1.35 in.	1.35" x 7,406 sf / 89,905 sf = 0.11 in.
2c	Enhanced Filter	7,406 sf	250 cf	250 cf	0.78 in.	0.78" x 7,406 sf / 89,905 sf = 0.06 in.
2d	Micro-Bioretention #4	5,851 sf	294 cf	37 cf	1.02 in.	1.02" x 5,851 sf / 89,905 sf = 0.07 in.
2d	Enhanced Filter	5,851 sf	200 cf	200 cf	0.70 in.	0.70" x 5,851 sf / 89,905 sf = 0.05 in.
2e	Micro-Bioretention #5	6,067 sf	235 cf	27 cf	1.13 in.	1.13" x 6,067 sf / 89,905 sf = 0.08 in.
2e	Enhanced Filter	6,067 sf	148 cf	148 cf	0.71 in.	0.71" x 6,067 sf / 89,905 sf = 0.05 in.
2f	Micro-Bioretention #6	3,602 sf	169 cf	16 cf	1.34 in.	1.34" x 3,602 sf / 89,905 sf = 0.05 in.
2f	Enhanced Filter	3,602 sf	104 cf	104 cf	0.82 in.	0.82" x 3,602 sf / 89,905 sf = 0.03 in.
2g	Rain Garden #2	1,150 sf	101 cf	7 cf	1.92 in.	1.92" x 1,150 sf / 89,905 sf = 0.02 in.
2g	Enhanced Filter	1,150 sf	39 cf	39 cf	0.74 in.	0.74" x 1,150 sf / 89,905 sf = 0.01 in.
2h	Rain Garden #3	1,744 sf	100 cf	9 cf	1.43 in.	1.43" x 1,744 sf / 89,905 sf = 0.03 in.
2h	Enhanced Filter	1,744 sf	66 cf	66 cf	0.95 in.	0.95" x 1,744 sf / 89,905 sf = 0.02 in.
2i	Rain Garden #4	860 sf	45 cf	3 cf	1.90 in.	1.90" x 860 sf / 89,905 sf = 0.02 in.
2i	Enhanced Filter	860 sf	14 cf	14 cf	0.59 in.	0.59" x 860 sf / 89,905 sf = 0.01 in.
2j	Rain Garden #5	1,042 sf	58 cf	6 cf	1.34 in.	1.34" x 1,042 sf / 89,905 sf = 0.02 in.
2j	Enhanced Filter	1,042 sf	36 cf	36 cf	0.83 in.	0.83" x 1,042 sf / 89,905 sf = 0.01 in.
2k	Rain Garden #6	1,029 sf	72 cf	4 cf	2.33 in.	2.33" x 1,029 sf / 89,905 sf = 0.03 in.
2k	Enhanced Filter	1,029 sf	9 cf	9 cf	0.29 in.	0.29" x 1,029 sf / 89,905 sf = 0.00 in.
2l	Rain Garden #7	1,625 sf	89 cf	5 cf	1.22 in.	1.22" x 1,625 sf / 89,905 sf = 0.02 in.
2l	Enhanced Filter	1,625 sf	46 cf	46 cf	0.63 in.	0.63" x 1,625 sf / 89,905 sf = 0.01 in.
2m	Rain Garden #8	885 sf	48 cf	5 cf	1.21 in.	1.21" x 885 sf / 89,905 sf = 0.01 in.
2m	Enhanced Filter	885 sf	22 cf	22 cf	0.55 in.	0.55" x 885 sf / 89,905 sf = 0.01 in.
2n	Rain Garden #9	690 sf	41 cf	3 cf	1.55 in.	1.55" x 690 sf / 89,905 sf = 0.01 in.
2n	Enhanced Filter	690 sf	18 cf	18 cf	0.68 in.	0.68" x 690 sf / 89,905 sf = 0.01 in.
2o	Submerged Gravel Wetland #1	89,905 sf	3,950 cf	477 cf	1.10 in.	1.10" x 89,905 sf / 89,905 sf = 1.10 in.
		Totals:	**6,806 cf**	**1,638 cf**		**Total Weighted P_E Value = 1.9 in.**
		Targets:	**6,608 cf**	**479 cf**		**Target P_E = 1.8 in.**
		ESD_V Provided:	**6,806 cf**			
		Additional Q_P Storage:	**0 cf**			
P_E Achieved = $(12 \times ESD_V)/(R_V \times AREA)$ = (12 x 6,806c.f.) / (0.49 x 89,905sf) = 1.9 in.						

III-c. Environmental Site Design – Drainage Area #3

Drainage Area #3 contains the rear of lots 4, 5 and 6, as well as offsite properties between those lots and Tyler Avenue. One of the offsite properties, located at 915 Tyler Avenue, is currently under construction with an approved grading permit, GRD14-0038. The stormwater management proposed under that grading permit was included in the computations for this drainage area. This area drains to a sump at the northern property line of the subject property. A submerged gravel wetlands with a bio-swale forebay is proposed for qualitative rainwater management, and the proposed storm drain system will collect overflow and convey it to the existing storm drain system within Bay Ridge Avenue.

Soils in this drainage area have a type "C" hydrologic classifications; the Target RCN for "woods in good condition" is 70. The proposed imperviousness for the development area is 27%. Utilizing Table 5.3 from the State Manual, a target rainfall depth (P_E) of 1.6" and a target runoff depth (Q_E) of 0.46" were determined. From these initial computations, a minimum Environmental Site Design Volume (ESD_V) of 972 c.f. of runoff would need to be managed, of which 79 c.f. would need to be Recharge Volume (Re_V).

ESD for this drainage area is achieved through the use of disconnects, a rain garden with an enhanced filter, and a submerged gravel wetlands. The ESD_V provided is 1,050 c.f., and the Re_V is 157 c.f. Both of these volumes are greater than the targets, and therefore, ESD is achieved to the MEP. The proposed development mimics "woods in good conditions" and satisfies channel protection obligations through the Reduced Runoff Curve Number Method.

Drum, Loyka, & Associates LLC

Designer:	DE	Date: August 21, 2015	Checked By: WB	Date:
Title:	Griscom Square			Job No.: BP12804
Subject:	ESD Design			Sheet No. of

Site Data (Drainage Area 3):

Location: Tyler Avenue, Annapolis, MD							
Drainage Area (DA):		25,140 sf	or	0.58 Ac.			
Soils:	HSG 'A' =	0 sf	or	0 Ac.	or	0 %	of Site
	HSG 'B' =	0 sf	or	0 Ac.	or	0 %	of Site
	HSG 'C' =	25,140 sf	or	0.58 Ac.	or	100 %	of Site
	HSG 'D' =	0 sf	or	0 Ac.	or	0 %	of Site

Proposed Impervious Surfaces =	6,735 sf	or	0.15 Ac.
Proposed Alternative Surfaces =	0 sf	or	0.00 Ac.
Proposed Hard Surfaces =	6,735 sf	or	0.15 Ac.

Step 1: Determine ESD Implementation Goals

A. Determine Pre-Developed Conditions:

Soil Conditions and RCNs for "woods in good condition"

HSG	RCN*	Area	Percent
A	38	0.00 Ac.	0.00
B	55	0.00 Ac.	0.00
C	70	0.58 Ac.	100.00
D	77	0.00 Ac.	0.00

* RCN for "woods in good condition" *(Table 2-2, TR-55)*

** Actual RCN is less than 30, use RCN = 38

Composite RCN for "woods in good condition"

RCN_{woods} = [(38x0.00ac)+(55x0.00ac)+(70x0.58ac)+(77x0.00ac)] / 0.58ac

RCN_{woods} = 70

Target RCN for "woods in good condition" = $\boxed{70}$

B. Determine Target P_E Using Table 5.3

P_E = Rainfall used to size ESD practices

Proposed imperviousness (%I)

Proposed Impervious Area: 6,735 sf *from Site Data Table, above*

%I = Imp. Area / Drainage Area = 6,735sf / 25,140sf = 26.79 % = $\boxed{27\ \%}$

- Determine P_E from Table

Hydrologic Soil Group 'A'										
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	40									
5%	43									
10%	46									
15%	48	**38**								
20%	51	40	**38**	**38**						
25%	54	41	40	39						
30%	57	42	41	39	**38**					
35%	60	44	42	40	39					
40%	61	44	42	40	39					
45%	66	48	46	41	40					
50%	69	51	48	42	41	**38**				
55%	72	54	50	42	41	39				
60%	74	57	52	44	42	40	**38**			
65%	77	61	55	47	44	42	40			
70%	80	66	61	55	50	45	40			
75%	84	71	67	62	56	48	40	**38**		
80%	86	73	70	65	60	52	44	40		
85%	89	77	74	70	65	58	49	42	**38**	
90%	92	81	78	74	70	65	58	48	42	**38**
95%	95	85	82	78	75	70	65	57	50	39
100%	98	89	86	83	80	76	72	66	59	40

Use P_E = 0.0 inches of rainfall as the target for ESD implementation

Hydrologic Soil Group 'B'										
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	61									
5%	63									
10%	65									
15%	67	**55**								
20%	68	60	**55**	**55**						
25%	70	64	61	58						
30%	72	65	62	59	**55**					
35%	74	66	63	60	56					
40%	75	66	63	60	56					
45%	78	68	66	62	58					
50%	80	70	67	64	60					
55%	81	71	68	65	61	**55**				
60%	83	73	70	67	63	58				
65%	85	75	72	69	65	60	**55**			
70%	87	77	74	71	67	62	57			
75%	89	79	76	73	69	65	59			
80%	91	81	78	75	71	66	61			
85%	92	82	79	76	72	67	62	**55**		
90%	94	84	81	78	74	70	65	59	**55**	
95%	96	87	84	81	77	73	69	63	57	
100%	98	89	86	83	80	76	72	66	59	**55**

Use P_E = 1.2 inches of rainfall as the target for ESD implementation

Hydrologic Soil Group 'C'										
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	74									
5%	75									
10%	76									
15%	78									
20%	79	**70**								
25%	80	72	**70**	**70**						
30%	81	73	72	71						
35%	82	74	73	72	**70**					
40%	84	77	75	73	71					
45%	85	78	76	74	71					
50%	86	78	76	74	71					
55%	86	78	76	74	71	**70**				
60%	88	80	78	76	73	71				
65%	90	82	80	77	75	72				
70%	91	82	80	78	75	72				
75%	92	83	81	79	75	72				
80%	93	84	82	79	76	72				
85%	94	85	82	79	76	72				
90%	95	86	83	80	77	73	**70**			
95%	97	88	85	82	79	75	71			
100%	98	89	86	83	80	76	72	**70**		

Use P_E = 1.6 inches of rainfall as the target for ESD implementation

Hydrologic Soil Group 'D'										
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	80									
5%	81									
10%	82									
15%	83									
20%	84	**77**								
25%	85	78								
30%	85	78	**77**	**77**						
35%	86	79	78	78						
40%	87	82	81	79	**77**					
45%	88	82	81	79	78					
50%	89	83	82	80	78					
55%	90	84	82	80	78					
60%	91	85	83	81	78					
65%	92	85	83	81	78					
70%	93	86	84	81	78					
75%	94	86	84	81	78					
80%	94	86	84	92	79					
85%	95	86	84	82	79					
90%	96	87	84	82	79	**77**				
95%	97	88	85	82	80	78				
100%	98	89	86	83	80	78	**77**			

Use P_E = 0.0 inches of rainfall as the target for ESD implementation

Compute Composite P_E:

HSG	Area	Target P_E		Net P_E
A	0.00 ac	0.0	0.00 ac x 0.00 / 0.58 ac =	0.0
B	0.00 ac	1.2	0.00 ac x 1.20 / 0.58 ac =	0.0
C	0.58 ac	1.6	0.58 ac x 1.60 / 0.58 ac =	1.6
D	0.00 ac	0.0	0.00 ac x 0.00 / 0.58 ac =	0.0
			Composite P_E =	**1.6**

C. Compute Q_E:

Q_E = Runoff depth used to size ESD practices

$Q_E = P_E * R_V$, where:

P_E = 1.6 in *(from above)*

$R_V = 0.05 + (0.009)(I)$; I = 26.79 %

$= 0.05 + 0.009 \times (26.79)$

$= 0.29$

Q_E = 1.6 " x 0.29

= **0.46 inches**

ESD Target for the Project

P_E = 1.6 Inches *composite P_E, from above*

Q_E = 0.46 Inches

D. Compute Target ESD_V & Re_V for Drainage Area 3:

Required Environmental Site Design Volume (ESD_V) for DA3:

$$ESD_V = [(P_E) \times (R_V) \times (DA)]/ 12$$

where: Target P_E = 1.60 in. *(from Table 5.3, above)*

R_V = 0.29 *(from Q_E, above)*

DA = 25,140 sf or 0.58 ac *(from Site Tabulations, above)*

Target ESD_V = [(1.60 in.) x (0.29) x (25,140 sf)] / 12 =

= **972 cf**

Required Minimum Recharge Volume (Re_V) for DA3:

$$Re_V = [(S) \times (R_V) \times (DA)]/ 12$$

Where:

Composite 'S' =

HSG	Area	Recharge Factor		Net 'S'
A	0.00 ac	0.38	0.00 ac x 0.38 / 0.58 ac	0.00
B	0.00 ac	0.26	0.00 ac x 0.26 / 0.58 ac	0.00
C	0.58 ac	0.13	0.58 ac x 0.13 / 0.58 ac	0.13
D	0.00 ac	0.07	0.00 ac x 0.07 / 0.58 ac	0.00
			Composite 'S' =	**0.13**

R_V = 0.29 *from WQ_V, above*

DA = 25,140 sf or 0.58 ac

Min. Re_V = [(0.13) x (0.29) x (25,140)] /12

= **79 cf**

E. Compute P_E Value & ESD_V or Project

DA-3a

ESD Practice N-1 Disconnection of Rooftop Runoff					
Rooftop Surface	Roof Area	Soil Type	Disconnect Length	Average Slope	Weighted P_E Value
Lot 6 Roof	132 sf	C	30 ft.	3.0 %	0.40 in.
	sf	C	ft.	%	in.
	sf	C	ft.	%	in.
	sf	C	ft.	%	in.
	sf	C	ft.	%	in.
Totals:	**132 sf**				**0.40 in.**

ESD_V = [(P_E) x (R_V) x (A)]/ 12

where: P_E = 0.40 in. *(from above)*

R_V = 0.05 + (0.009 x %I)

= 0.05 + (0.009 x 100%)

= 0.95

A = 132 sf or 0.00 ac

ESD_V = (0.40 in. x 0.95 x 132 sf) / 12

= **4 cf**

Re_V = [(S) x (R_V) x (A)]/ 12

S = 0.13 *composite 'S' from above*

R_V = 0.05 + (0.009 x %I)

= 0.05 + (0.009 x 100%)

= 0.95

A = 132 sf or 0.00 ac

Re_V = [(0.13) x (0.95) x (132)] /12

= **1 cf**

DA 3b | ESD Practice M-7 Rain Garden - GRD14-0038

Contributing Drainage Area (DA) = 2,000 sf or 0.05 Ac.
Impervious Surfaces in DA = 834 sf or 0.02 Ac.
%I = 834 sf / 2,000 sf = 42 %
Surface Area (A_f) = 76 sf

ESD_V Concept Design Estimate:

ESD_V = [(P_E) x (R_V) x (DA)]/12
where: P_E = 10 in x (A_f/DA) *(Eqn. 5.3, MDE)*
= 10 in x (76 sf / 2,000 sf)
P_E = $\boxed{0.38 \text{ in.}}$ ***(Concept Design Estimate)***
R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 42%)
= $\boxed{0.43}$
ESD_V = (0.38 in. x 0.43 x 2,000 sf) / 12
= $\boxed{27 \text{ cf}}$ ***(Concept Design Estimate)***
Re_V = [(S) x (R_V) x (DA)]/ 12 if $P_E \geq S$
S = $\boxed{0.13}$ *Composite 'S' from above*
Re_V = [(0.13) x (0.43) x (2,000 sf)] /12 =
= $\boxed{9 \text{ cf}}$

ESD_V based on volume stored

Micro-Bioretention Design:

Filter Media Depth = 0.50 ft
Pea Gravel Depth = 0.33 ft *(4" of #8)*
Gravel Depth = 0.50 ft *(6" of #57, Gravel Jacket for underdrain)*
Media Porosity = 0.4
Media Storage Volume = [76sf x (0.50ft.+ 0.33ft.+ 0.50ft.) x 0.4]
= $\boxed{40 \text{ cf}}$
Ponding Depth = 0.50 ft
Side Slopes = 3:1
Max. Water Surface Area = 188 sf
Ponding Storage Volume = [((188sf + 76sf) / 2) x 0.50ft.]
= $\boxed{66 \text{ cf}}$
ESD_V Storage provided = 40cf + 66cf
= $\boxed{\mathbf{106 \text{ cf}}}$
P_E Provided = (ESD_V x 12)/(R_V x DA) *Based on ESD_V stored*
= (106cf x 12)/(0.43 x 2,000sf)
= $\boxed{\mathbf{1.48 \text{ in.}}}$

DA-3b | BMP M-9 Enhanced Filter - GRD14-0038

Filter bed area (A_f) = 76 sf *from above*
Media Porosity (n) = 0.40
Depth of stone storage (d) = 2.25 ft *(#57 stone)*
Additional ESDV provided = (A_f x n x d)
= 76sf x 0.40 x 2.25ft.
= $\boxed{\mathbf{68 \text{ cf}}}$
P_E Provided = (12 x ESD_V)/(R_V x A)
= (12 x 68cf) / (0.43 x 2,000sf)
= $\boxed{\mathbf{0.95 \text{ in.}}}$

DA-3c: ESD Practice M-2 Submerged Gravel Wetland

Contributing Drainage Area = 25,140 sf or 0.58 Ac.
Impervious Surfaces in DA = 6,735 sf or 0.15 Ac.
%I = 6,735 sf / 25,140 sf = 27 %

ESD_V: Runoff volume managed by ESD practice

Target ESD_V = $[(P_E) \times (R_V) \times (DA)]/12$

Target P_E = $\boxed{1.60 \text{ in.}}$

R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 27%)
= 0.29

= [(1.60in.) x (0.29) x (25,140sf)] / 12 = $\boxed{972 \text{ cf}}$

Re_V = $[(S) \times (R_V) \times (DA)]/12$

= [(0.00) x (0.29) x (25,140sf)] /12 = $\boxed{79 \text{ cf}}$

Submerged Gravel Wetland Design:

Bio-swale Forebay Design:

Forebay Surface Area = 157 sf *(El. 27.0 - 28.0)*
Filter Media Depth = 2.00 ft
Pea Gravel Depth = 0.50 ft *(6" of #8 Gravel)*
Gravel Depth = 1.00 ft *(12" of #57 Gravel)*
Media Porosity = 0.4
Storage Volume = [157sf x (2.00ft. + 0.50ft.+ 1.00) x 0.4]
= **220 cf**
Side Slopes = 5:1
Forebay Depth = 0.25 ft *(From 10-yr Storm)*
Water Surface Area = 240 sf
Ponding Storage Volume = [((157sf + 240sf) / 2) x 0.25ft.]
= **50 cf**
Forebay Storage Volume Provided = 220cf + 50cf
= **270 cf**

Gravel Wetland Design:

Wetland Surface area = 330 sf *(El 26.5)*
Ponding Depth = 0.50 ft
Side Slopes = 3:1
Max. Water Surface Area = 540 sf
Ponding Storage Volume = [((540sf + 330sf) /2) x 0.50ft.]
218 cf

Planting Media = 1.0 ft
Pea Gravel Bridge = 0.5 ft
Gravel substrate depth = 2.0 ft

Additional Ponded Storage Provided, from weir elevation to top
Base Water Surface Area = 540 sf
Ponding Depth = 0.50 ft
Side Slopes = 3:1
Max. Water Surface Area = 997 sf
Ponding Storage Volume = [((997sf + 540sf) /2) x 0.50ft.]
= **384 cf**

Wetland Storage Provided **602 cf**

Total Storage Volume = 270cf + 602cf
= **872 cf**

P_E Provided = **1.4 in.** *(based on total storage volume)*

P_E & ESD_V Summary:

Microscale & Non-Structural Practices						
DA #	ESD Practice	DA	ESD_V	Re_V	P_E Value	Weighted P_E Value
3a	Disconnection of Rooftop Runoff	132 sf	4 cf	1 cf	0.40 in.	0.40" x 132 sf / 25,140 sf = 0.00 in.
3b	Rain Garden - GRD14-0038	2,000 sf	106 cf	9 cf	1.48 in.	1.48" x 2,000 sf / 25,140 sf = 0.12 in.
3b	Enhanced Filter - GRD14-0038	2,000 sf	68 cf	68 cf	0.95 in.	0.95" x 2,000 sf / 25,140 sf = 0.08 in.
3c	Submerged Gravel Wetland	25,140 sf	872 cf	79 cf	1.40 in.	1.40" x 25,140 sf / 25,140 sf = 1.40 in.
		Totals:	**1,050 cf**	**157 cf**		**Total Weighted P_E Value = 1.6 in.**
		Targets:	**972 cf**	**79 cf**		**Target P_E = 1.6 in.**
		ESD_V Provided:	**1,050 cf**			
		Additional Q_P Storage:	**0 cf**			
P_E Achieved = $(12 \times ESD_V)/(R_V \times AREA)$ = (12 x 1,050c.f.) / (0.29 x 25,140sf) =						**1.7 in.**

III-d. Environmental Site Design – Drainage Area #4

Drainage Area #4 contains the rear of lots 7, 8 and 9, and the open space at the southern end of the subject property. This area outfalls to the right-of-way for Cedar Ridge, and the private property to the west. Runoff from this drainage area is managed at or near the source by disconnection of runoff and micro practices.

Soils in this drainage area have a type "C" hydrologic classifications; the Target RCN for "woods in good condition" is 70. The proposed imperviousness for the development area is 12%. Utilizing Table 5.3 from the State Manual, a target rainfall depth (P_E) of 1.0" and a target runoff depth (Q_E) of 0.16" were determined. From these initial computations, a minimum Environmental Site Design Volume (ESD_V) of 305 c.f. of runoff would need to be managed, of which 40 c.f. would need to be Recharge Volume (Re_V).

ESD for this drainage area is achieved through disconnection of rooftop runoff, and two submerged gravel wetlands. The ESD_V provided is 307 c.f., and the Re_V is 41 c.f. Both of these volumes are greater than the targets, and therefore, ESD is achieved to the MEP. The proposed development mimics "woods in good conditions" and satisfies channel protection obligations through the Reduced Runoff Curve Number Method.

Drum, Loyka, & Associates LLC

Designer: DE	Date: August 19, 2015	Checked By: WB	Date:
Title: Griscom Square			Job No.: BP12804
Subject: ESD Design			Sheet No. of

Site Data (Drainage Area 4):

Location: Tyler Avenue, Annapolis, MD							
Drainage Area (DA):		22,907 sf	or	0.53 Ac.			
Soils:	HSG 'A' =	0 sf	or	0 Ac.	or	0 %	of Site
	HSG 'B' =	0 sf	or	0 Ac.	or	0 %	of Site
	HSG 'C' =	22,907 sf	or	0.53 Ac.	or	100 %	of Site
	HSG 'D' =	0 sf	or	0 Ac.	or	0 %	of Site

Proposed On-site Impervious Surfaces =	2,776 sf	or	0.06 Ac.

Step 1: Determine ESD Implementation Goals

A. Determine Pre-Developed Conditions:

Soil Conditions and RCNs for "woods in good condition"

HSG	RCN*	Area	Percent
A	38	0.00 Ac.	0.00
B	55	0.00 Ac.	0.00
C	70	0.53 Ac.	100.00
D	77	0.00 Ac.	0.00

* RCN for "woods in good condition" (*Table 2-2, TR-55*)

** Actual RCN is less than 30, use RCN = 38

Composite RCN for "woods in good condition"

RCN_{woods} = [(38x0.00ac)+(55x0.00ac)+(70x0.53ac)+(77x0.00ac)] / 0.53ac

RCN_{woods} = 70

Target RCN for "woods in good condition" = $\boxed{70}$

B. Determine Target P_E Using Table 5.3

P_E = Rainfall used to size ESD practices

Proposed imperviousness (%I)

Proposed Impervious Area: 2,776 sf *from Site Data Table, above*

%I = Imp. Area / Drainage Area = 2,776sf / 22,907sf = 12.12 % = $\boxed{12\ \%}$

- Determine P_E from Table

Hydrologic Soil Group 'A'											
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	40									
5%	43									
10%	46									
15%	48	**38**								
20%	51	40	**38**	**38**						
25%	54	41	40	39						
30%	57	42	41	39	**38**					
35%	60	44	42	40	39					
40%	61	44	42	40	39					
45%	66	48	46	41	40					
50%	69	51	48	42	41	**38**				
55%	72	54	50	42	41	39				
60%	74	57	52	44	42	40	**38**			
65%	77	61	55	47	44	42	40			
70%	80	66	61	55	50	45	40			
75%	84	71	67	62	56	48	40	**38**		
80%	86	73	70	65	60	52	44	40		
85%	89	77	74	70	65	58	49	42	**38**	
90%	92	81	78	74	70	65	58	48	42	**38**
95%	95	85	82	78	75	70	65	57	50	39
100%	98	89	86	83	80	76	72	66	59	40

Use P_E = 0.0 inches of rainfall as the target for ESD implementation

Hydrologic Soil Group 'B'										
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	61									
5%	63									
10%	65									
15%	67	**55**								
20%	68	60	**55**	**55**						
25%	70	64	61	58						
30%	72	65	62	59	**55**					
35%	74	66	63	60	56					
40%	75	66	63	60	56					
45%	78	68	66	62	58					
50%	80	70	67	64	60					
55%	81	71	68	65	61	**55**				
60%	83	73	70	67	63	58				
65%	85	75	72	69	65	60	**55**			
70%	87	77	74	71	67	62	57			
75%	89	79	76	73	69	65	59			
80%	91	81	78	75	71	66	61			
85%	92	82	79	76	72	67	62	**55**		
90%	94	84	81	78	74	70	65	59	**55**	
95%	96	87	84	81	77	73	69	63	57	
100%	98	89	86	83	80	76	72	66	59	**55**

Use P_E = 0.0 inches of rainfall as the target for ESD implementation

Hydrologic Soil Group 'C'										
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	74									
5%	75									
10%	76									
15%	78									
20%	79	**70**								
25%	80	72	**70**	**70**						
30%	81	73	72	71						
35%	82	74	73	72	**70**					
40%	84	77	75	73	71					
45%	85	78	76	74	71					
50%	86	78	76	74	71					
55%	86	78	76	74	71	**70**				
60%	88	80	78	76	73	71				
65%	90	82	80	77	75	72				
70%	91	82	80	78	75	72				
75%	92	83	81	79	75	72				
80%	93	84	82	79	76	72				
85%	94	85	82	79	76	72				
90%	95	86	83	80	77	73	**70**			
95%	97	88	85	82	79	75	71			
100%	98	89	86	83	80	76	72	**70**		

Use P_E = 1.0 inches of rainfall as the target for ESD implementation

Hydrologic Soil Group 'D'										
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	80									
5%	81									
10%	82									
15%	83									
20%	84	**77**								
25%	85	78								
30%	85	78	**77**	**77**						
35%	86	79	78	78						
40%	87	82	81	79	**77**					
45%	88	82	81	79	78					
50%	89	83	82	80	78					
55%	90	84	82	80	78					
60%	91	85	83	81	78					
65%	92	85	83	81	78					
70%	93	86	84	81	78					
75%	94	86	84	81	78					
80%	94	86	84	92	79					
85%	95	86	84	82	79					
90%	96	87	84	82	79	**77**				
95%	97	88	85	82	80	78				
100%	98	89	86	83	80	78	**77**			

Use P_E = 0.0 inches of rainfall as the target for ESD implementation

Compute Composite P_E:

HSG	Area	Target P_E		Net P_E
A	0.00 ac	0.0	0.00 ac x 0.00 / 0.53 ac =	0.0
B	0.00 ac	0.0	0.00 ac x 0.00 / 0.53 ac =	0.0
C	0.53 ac	1.0	0.53 ac x 1.00 / 0.53 ac =	1.0
D	0.00 ac	0.0	0.00 ac x 0.00 / 0.53 ac =	0.0
			Composite P_E =	**1.0**

C. Compute Q_E:

Q_E = Runoff depth used to size ESD practices

$Q_E = P_E * R_V$, where:

P_E = 1.0 in *(from above)*

$R_V = 0.05 + (0.009)(I)$; I = 12.12 %

$= 0.05 + 0.009 \times (12.12)$

$= 0.16$

Q_E = 1.0 " x 0.16

= **0.16 inches**

<u>ESD Target for the Project</u>

P_E = $\boxed{\textbf{1.0 Inches}}$ *composite P_E, from above*

Q_E = $\boxed{\textbf{0.16 Inches}}$

D. Compute Target ESD_V & Re_V for Drainage Area 4:

Required Environmental Site Design Volume (ESD_V) for DA4:

$$ESD_V = [(P_E) \times (R_V) \times (DA)] / 12$$

where: Target P_E = $\boxed{1.00\text{ in.}}$ *(from Table 5.3, above)*

R_V = $\boxed{0.16}$ *(from Q_E, above)*

DA = $\boxed{22{,}907\text{ sf}}$ or 0.53 ac *(from Site Tabulations, above)*

Target ESD_V = [(1.00 in.) x (0.16) x (22,907 sf)] / 12 =

= $\boxed{\textbf{305 cf}}$

Required Minimum Recharge Volume (Re_V) for DA4:

$$Re_V = [(S) \times (R_V) \times (DA)] / 12$$

Where:

Composite 'S' =

HSG	Area	Recharge Factor		Net 'S'
A	0.00 ac	0.38	0.00 ac x 0.38 / 0.53 ac	0.00
B	0.00 ac	0.26	0.00 ac x 0.26 / 0.53 ac	0.00
C	0.53 ac	0.13	0.53 ac x 0.13 / 0.53 ac	0.13
D	0.00 ac	0.07	0.00 ac x 0.07 / 0.53 ac	0.00
			Composite 'S' =	**0.13**

R_V = $\boxed{0.16}$ *from WQ_V, above*

DA = $\boxed{22{,}907\text{ sf}}$ or 0.53 ac

Min. Re_V = [(0.13) x (0.16) x (22,907)] /12

= $\boxed{\textbf{40 cf}}$

E. Compute P_E Value & ESD_V or Project

DA-4a: ESD Practice N-1 Disconnection of Rooftop Runoff

Rooftop Surface	Roof Area	Soil Type	Disconnect Length	Average Slope	Weighted P_E Value
Lot 7 - Roof Area A	341 sf	C	30 ft.	2.0 %	0.40 in.
Lot 7 - Roof Area B	121 sf	C	15 ft.	2.0 %	0.20 in.
Lot 9 - Roof Area A	347 sf	C	15 ft.	2.0 %	0.20 in.
Lot 9 - Roof Area B	294 sf	C	75 ft.	2.0 %	1.00 in.
Lot 9 - Roof Area C	406 sf	C	75 ft.	1.0 %	1.00 in.
Lot 9 - Roof Area D	259 sf	C	15 ft.	1.0 %	0.20 in.
p/o Garage - Lot 9	264 sf	C	75 ft.	2.0 %	1.00 in.
p/o Dwelling - Lot 8	611 sf	C	75 ft.	2.0 %	1.00 in.
Totals:	**2,643 sf**				**0.70 in.**

ESD_V = $[(P_E) \times (R_V) \times (A)]/12$

where: P_E = 0.70 in. *(from above)*

$R_V = 0.05 + (0.009 \times \%I)$

$= 0.05 + (0.009 \times 100\%)$

$= 0.95$

A = 2,643 sf or 0.06 ac

ESD_V = (0.70 in. x 0.95 x 2,643 sf) / 12

= **146 cf**

Re_V = $[(S) \times (R_V) \times (A)]/12$

S = 0.13 *composite 'S' from above*

$R_V = 0.05 + (0.009 \times \%I)$

$= 0.05 + (0.009 \times 100\%)$

$= 0.95$

A = 2,643 sf or 0.06 ac

Re_V = [(0.13) x (0.95) x (2,643)] /12

= **27 cf**

DA-4b: ESD Practice M-2 Submerged Gravel Wetland #3

Contributing Drainage Area = 2,313 sf or 0.05 Ac.

Impervious Surfaces in DA = 809 sf or 0.02 Ac.

%I = 809 sf / 2,313 sf = 35 %

ESD_V: Runoff volume managed by ESD practice

Target ESD_V = $[(P_E) \times (R_V) \times (DA)]/12$

Target P_E = 1.00 in.

$R_V = 0.05 + (0.009 \times \%I)$

$= 0.05 + (0.009 \times 35\%)$

$= 0.37$

= [(1.00in.) x (0.37) x (2,313sf)] / 12 = 71 cf

Re_V = $[(S) \times (R_V) \times (DA)]/12$

= [(0.13) x (0.37) x (2,313sf)] /12 = 9 cf

Submerged Gravel Wetland Design:

Gravel Wetland Design:

Wetland Surface area = 140 sf *(El 26.5)*

Ponding Depth = 0.50 ft

Side Slopes = 3:1

Max. Water Surface Area = 230 sf

Ponding Storage Volume = [((230sf + 140sf) /2) x 0.50ft.]

93 cf

Planting Media = 1.0 ft

Pea Gravel Bridge = 0.5 ft

Gravel substrate depth = 2.0 ft

Wetland Storage Provided **93 cf**

P_E Provided = **1.3 in.** *(based on total storage volume)*

DA-4c: ESD Practice M-2 Submerged Gravel Wetland #4

Contributing Drainage Area = 1,306 sf or 0.03 Ac.
Impervious Surfaces in DA = 391 sf or 0.01 Ac.
%I = 391 sf / 1,306 sf = 30 %

ESD_V: Runoff volume managed by ESD practice

Target ESD_V = $[(P_E) \times (R_V) \times (DA)]/12$

Target P_E = $\boxed{1.00 \text{ in.}}$

R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 30%)
= 0.32

= [(1.00in.) x (0.32) x (1,306sf)] / 12 = $\boxed{35 \text{ cf}}$

Re_V = $[(S) \times (R_V) \times (DA)]/ 12$

= [(0.13) x (0.32) x (1,306sf)] /12 = $\boxed{5 \text{ cf}}$

Submerged Gravel Wetland Design:

Gravel Wetland Design:

Wetland Surface area = 92 sf *(El 26.5)*
Ponding Depth = 0.50 ft
Side Slopes = 3:1
Max. Water Surface Area = 178 sf
Ponding Storage Volume = [((178sf + 92sf) /2) x 0.50ft.]
$\boxed{68 \text{ cf}}$

Planting Media = 1.0 ft
Pea Gravel Bridge = 0.5 ft
Gravel substrate depth = 2.0 ft

Wetland Storage Provided $\boxed{68 \text{ cf}}$

P_E Provided = $\boxed{2.0 \text{ in.}}$ *(based on total storage volume)*

P_E & ESD_V Summary:

Microscale & Non-Structural Practices						
DA #	ESD Practice	DA	ESD_V	Re_V	P_E Value	Weighted P_E Value
4a	Disconnection of Rooftop Runoff	2,643 sf	146 cf	27 cf	0.70 in.	0.70" x 2,643 sf / 22,907 sf = 0.08 in.
4b	Submerged Gravel Wetland #3	2,313 sf	93 cf	9 cf	1.30 in.	1.30" x 2,313 sf / 22,907 sf = 0.13 in.
4c	Submerged Gravel Wetland #4	1,306 sf	68 cf	5 cf	2.00 in.	2.00" x 1,306 sf / 22,907 sf = 0.11 in.
		sf	cf	cf	in.	0.00" x 0 sf / 22,907 sf = 0.00 in.
		sf	cf	cf	in.	0.00" x 0 sf / 22,907 sf = 0.00 in.
		Totals:	**307 cf**	**41 cf**		**Total Weighted P_E Value = 0.3 in.**
		Targets:	**305 cf**	**40 cf**		**Target P_E = 1.0 in.**
		ESD_V Provided:	**307 cf**			
		Additional Q_P Storage:	**0 cf**			
P_E Achieved = $(12 \times ESD_V)/(R_V \times AREA)$ = (12 x 307c.f.) / (0.16 x 22,907sf) =						**1.0 in.**

III-e. Environmental Site Design – Drainage Area #5

Drainage Area #5 contains the rear of lots 1, 3 and 10 at the northeastern end of the property. This area outfalls to the right-of-ways for both Tyler Avenue and Bay Ridge Avenue. Runoff from this drainage area is managed at or near the source by disconnection of runoff and micro practices.

Soils in this drainage area have a type "C" hydrologic classifications; the Target RCN for "woods in good condition" is 70. The proposed imperviousness for the development area is 22%. Utilizing Table 5.3 from the State Manual, a target rainfall depth (P_E) of 1.2" and a target runoff depth (Q_E) of 0.3" were determined. From these initial computations, a minimum Environmental Site Design Volume (ESD_V) of 242 c.f. of runoff would need to be managed, of which 26 c.f. would need to be Recharge Volume (Re_V).

ESD for this drainage area is achieved through the use of disconnection of non-rooftop runoff, and three drywells. The ESD_V provided is 290 c.f., and the Re_V is 287 c.f. Both of these volumes are greater than the targets, and therefore, ESD is achieved to the MEP. The proposed development mimics "woods in good conditions" and satisfies channel protection obligations through the Reduced Runoff Curve Number Method.

Drum, Loyka, & Associates LLC

Designer: DE	Date: August 21, 2015	Checked By: WB	Date:
Title: Griscom Square			Job No.: BP12804
Subject: ESD Design			Sheet No. of

Site Data (Drainage Area 5):

Location: Tyler Avenue, Annapolis, MD							
Drainage Area (DA):		9,666 sf	or	0.22 Ac.			
Soils:	HSG 'A' =	0 sf	or	0 Ac.	or	0 %	of Site
	HSG 'B' =	0 sf	or	0 Ac.	or	0 %	of Site
	HSG 'C' =	9,666 sf	or	0.22 Ac.	or	100 %	of Site
	HSG 'D' =	0 sf	or	0 Ac.	or	0 %	of Site

Proposed On-site Impervious Surfaces =	2,128 sf	or	0.05 Ac.
Proposed Off-site Impervious Surfaces =	0 sf	or	0.00 Ac.
Total Proposed Impervious Surfaces =	2,128 sf	or	0.05 Ac.

Step 1: Determine ESD Implementation Goals

A. Determine Pre-Developed Conditions:

Soil Conditions and RCNs for "woods in good condition"

HSG	RCN*	Area	Percent
A	38	0.00 Ac.	0.00
B	55	0.00 Ac.	0.00
C	70	0.22 Ac.	100.00
D	77	0.00 Ac.	0.00

* RCN for "woods in good condition" *(Table 2-2, TR-55)*

** Actual RCN is less than 30, use RCN = 38

Composite RCN for "woods in good condition"

RCN_{woods} = [(38x0.00ac)+(55x0.00ac)+(70x0.22ac)+(77x0.00ac)] / 0.22ac

RCN_{woods} = 70

Target RCN for "woods in good condition" = $\boxed{70}$

B. Determine Target P_E Using Table 5.3

P_E = Rainfall used to size ESD practices

Proposed imperviousness (%I)

Proposed Impervious Area: 2,128 sf *from Site Data Table, above*

%I = Imp. Area / Drainage Area = 2,128sf / 9,666sf = 22.02 % = $\boxed{22 \%}$

- Determine P_E from Table

Hydrologic Soil Group 'A'										
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	40									
5%	43									
10%	46									
15%	48	**38**								
20%	51	40	**38**	**38**						
25%	54	41	40	39						
30%	57	42	41	39	**38**					
35%	60	44	42	40	39					
40%	61	44	42	40	39					
45%	66	48	46	41	40					
50%	69	51	48	42	41	**38**				
55%	72	54	50	42	41	39				
60%	74	57	52	44	42	40	**38**			
65%	77	61	55	47	44	42	40			
70%	80	66	61	55	50	45	40			
75%	84	71	67	62	56	48	40	**38**		
80%	86	73	70	65	60	52	44	40		
85%	89	77	74	70	65	58	49	42	**38**	
90%	92	81	78	74	70	65	58	48	42	**38**
95%	95	85	82	78	75	70	65	57	50	39
100%	98	89	86	83	80	76	72	66	59	40

Use P_E = 0.0 inches of rainfall as the target for ESD implementation

Hydrologic Soil Group 'B'										
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	61									
5%	63									
10%	65									
15%	67	**55**								
20%	68	60	**55**	**55**						
25%	70	64	61	58						
30%	72	65	62	59	**55**					
35%	74	66	63	60	56					
40%	75	66	63	60	56					
45%	78	68	66	62	58					
50%	80	70	67	64	60					
55%	81	71	68	65	61	**55**				
60%	83	73	70	67	63	58				
65%	85	75	72	69	65	60	**55**			
70%	87	77	74	71	67	62	57			
75%	89	79	76	73	69	65	59			
80%	91	81	78	75	71	66	61			
85%	92	82	79	76	72	67	62	**55**		
90%	94	84	81	78	74	70	65	59	**55**	
95%	96	87	84	81	77	73	69	63	57	
100%	98	89	86	83	80	76	72	66	59	**55**

Use P_E = 0.0 inches of rainfall as the target for ESD implementation

Hydrologic Soil Group 'C'											
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	74									
5%	75									
10%	76									
15%	78									
20%	79	**70**								
25%	80	72	**70**	**70**						
30%	81	73	72	71						
35%	82	74	73	72	**70**					
40%	84	77	75	73	71					
45%	85	78	76	74	71					
50%	86	78	76	74	71					
55%	86	78	76	74	71	**70**				
60%	88	80	78	76	73	71				
65%	90	82	80	77	75	72				
70%	91	82	80	78	75	72				
75%	92	83	81	79	75	72				
80%	93	84	82	79	76	72				
85%	94	85	82	79	76	72				
90%	95	86	83	80	77	73	**70**			
95%	97	88	85	82	79	75	71			
100%	98	89	86	83	80	76	72	**70**		

Use P_E = 1.2 inches of rainfall as the target for ESD implementation

Hydrologic Soil Group 'D'										
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	80									
5%	81									
10%	82									
15%	83									
20%	84	**77**								
25%	85	78								
30%	85	78	**77**	**77**						
35%	86	79	78	78						
40%	87	82	81	79	**77**					
45%	88	82	81	79	78					
50%	89	83	82	80	78					
55%	90	84	82	80	78					
60%	91	85	83	81	78					
65%	92	85	83	81	78					
70%	93	86	84	81	78					
75%	94	86	84	81	78					
80%	94	86	84	92	79					
85%	95	86	84	82	79					
90%	96	87	84	82	79	**77**				
95%	97	88	85	82	80	78				
100%	98	89	86	83	80	78	**77**			

Use P_E = 0.0 inches of rainfall as the target for ESD implementation

Compute Composite P_E:

HSG	Area	Target P_E		Net P_E
A	0.00 ac	0.0	0.00 ac x 0.00 / 0.22 ac =	0.0
B	0.00 ac	0.0	0.00 ac x 0.00 / 0.22 ac =	0.0
C	0.22 ac	1.2	0.22 ac x 1.20 / 0.22 ac =	1.2
D	0.00 ac	0.0	0.00 ac x 0.00 / 0.22 ac =	0.0
			Composite P_E =	**1.2**

C. Compute Q_E:

Q_E = Runoff depth used to size ESD practices

$Q_E = P_E * R_V$, where:

P_E = 1.2 in *(from above)*

R_V = 0.05 + (0.009)(I); I = 22.02 %

= 0.05 + 0.009 x (22.02)

= 0.25

Q_E = 1.2 " x 0.25

= **0.3 inches**

ESD Target for the Project

P_E = 1.2 Inches *composite P_E, from above*

Q_E = 0.3 Inches

D. Compute Target ESD_V & Re_V for Drainage Area 5:

Required Environmental Site Design Volume (ESD_V) for DA5:

ESD_V = [(P_E) x (R_V) x (DA)]/ 12

where: Target P_E = 1.20 in. *(from Table 5.3, above)*

R_V = 0.25 *(from Q_E, above)*

DA = 9,666 sf or 0.22 ac *(from Site Tabulations, above)*

Target ESD_V = [(1.20 in.) x (0.25) x (9,666 sf)] / 12 =

= **242 cf**

Required Minimum Recharge Volume (Re_V) for DA5:

Re_V = [(S) x (R_V) x (DA)]/ 12

Where:

Composite 'S' =

HSG	Area	Recharge Factor		Net 'S'
A	0.00 ac	0.38	0.00 ac x 0.38 / 0.22 ac	0.00
B	0.00 ac	0.26	0.00 ac x 0.26 / 0.22 ac	0.00
C	0.22 ac	0.13	0.22 ac x 0.13 / 0.22 ac	0.13
D	0.00 ac	0.07	0.00 ac x 0.07 / 0.22 ac	0.00
			Composite 'S' =	**0.13**

R_V = 0.25 *from WQ_V, above*

DA = 9,666 sf or 0.22 ac

Min. Re_V = [(0.13) x (0.25) x (9,666)] /12

= **26 cf**

E. Compute P_E Value & ESD_V or Project

DA-5a: ESD Practice N-2 Disconnection of Non-Rooftop Runoff

Surface Description	Non-Rooftop	Soil HSG	Contributing Length	Disconnect Length	Average Slope	P_E Value
Porch - Lot 10	56 sf	C	8 ft.	10 ft.	<5 %	1.00 in.
	sf	C	ft.	ft.	%	1.00 in.
	sf	C	ft.	ft.	%	1.00 in.
	sf	C	ft.	ft.	%	1.00 in.
Totals:	**56 sf**					**1.00 in.**

$ESD_V = [(P_E) \times (R_V) \times (A)] / 12$

where: P_E = 1.00 in. *(from chart above)*

$R_V = 0.05 + (0.009 \times \%I)$

$= 0.05 + (0.009 \times 100\%)$

$= 0.95$

A = 56 sf or 0.00 ac

$ESD_V = [(1.00 \text{ in.} \times 0.95 \times 56 \text{ sf})] / 12$

$= 4$ cf

$Re_V = [(S) \times (R_V) \times (A)] / 12$

S = 0.13 *composite 'S' from above*

$R_V = 0.05 + (0.009 \times \%I)$

$= 0.05 + (0.009 \times 100\%)$

$= 0.95$

A = 56 sf or 0.00 ac

$Re_V = [(0.13 \times 0.95 \times 56 \text{ sf})] / 12$

$= 1$ cf

DA-5b: ESD Practice M-5 Drywells

DA #	Roof Area	P_E	ESD_V	Drywell Storage (n = 0.4)							P_E Attained	HSG
5-b1	440 sf	1.2 in.	42 cf	4.00	x	7.00	x	8.00	=	90 cf	2.45 in.	C
5-b2	622 sf	1.2 in.	59 cf	6.00	x	9.00	x	5.50	=	119 cf	2.30 in.	C
5-b3	355 sf	1.2 in.	34 cf	4.00	x	8.00	x	6.00	=	77 cf	2.60 in.	C
	0 sf	0.0 in.	0 cf	0.00	x	0.00	x	0.00	=	0 cf	0.00 in.	C
Totals:	**1,417 sf Rooftop Area**							**ESD_V**	**=**	**286 cf**	**1.77 in. = P_E**	

P_E & ESD_V Summary:

Microscale & Non-Structural Practices							
DA #	ESD Practice	DA	ESD_V	Re_V	P_E Value	Weighted P_E Value	
5a	Drywells	1,417 sf	286 cf	286 cf	1.77 in.	1.77" x 1,417 sf / 9,666 sf =	0.26 in.
5b	Disconnection of Non-Rooftop Runoff	56 sf	4 cf	1 cf	1.00 in.	1.00" x 56 sf / 9,666 sf =	0.01 in.
		sf	cf	cf	in.	0.00" x 0 sf / 9,666 sf =	0.00 in.
		Totals:	**290 cf**	**287 cf**		**Total Weighted P_E Value =**	**0.3 in.**
		Targets:	**242 cf**	**26 cf**		**Target P_E =**	**1.2 in.**
		ESD_V Provided:	**290 cf**				
		Additional Q_P Storage:	**0 cf**				
P_E Achieved = $(12 \times ESD_V)/(R_V \times AREA)$ =						**(12 x 290c.f.) / (0.25 x 9,666sf) =**	**1.4 in.**

III-f. Environmental Site Design – Drainage Area #6

Drainage Area #6 contains the rear of lots 11 and 12 at the northwestern end of the property. This area drains to a sump at or near the property line. A micro-bioretention device is designed at the low point between lots 11 and 12 for qualitative management. The headwall for the proposed storm drain system is designed to collect overflow from the proposed micro-bioretention device, and some overland flow from the drainage area. Runoff from this drainage area is managed at or near the source by micro practices.

Soils in this drainage area have a type "C" hydrologic classifications; the Target RCN for "woods in good condition" is 70. The proposed imperviousness for the development area is 28%. Utilizing Table 5.3 from the State Manual, a target rainfall depth (P_E) of 1.6" and a target runoff depth (Q_E) of 0.50" were determined. From these initial computations, a minimum Environmental Site Design Volume (ESD_V) of 320 c.f. of runoff would need to be managed, of which 26 c.f. would need to be Recharge Volume (Re_V).

ESD for this drainage area is achieved through the use of a micro-bioretention device with an enhanced filter. The ESD_V provided is 385 c.f., and the Re_V is 88 c.f. Both of these volumes are greater than the targets, and therefore, ESD is achieved to the MEP. The proposed development mimics "woods in good conditions" and satisfies channel protection obligations through the Reduced Runoff Curve Number Method.

Drum, Loyka, & Associates LLC

Designer: DE	Date: August 21, 2015	Checked By: WB	Date:
Title: Griscom Square			Job No.: BP12804
Subject: ESD Design			Sheet No. of

Site Data (Drainage Area 6):

Location:	Tyler Avenue, Annapolis, MD						
Drainage Area (DA):		7,732 sf	or	0.18 Ac.			
Soils:	HSG 'A' =	0 sf	or	0 Ac.	or	0 %	of Site
	HSG 'B' =	0 sf	or	0 Ac.	or	0 %	of Site
	HSG 'C' =	7,732 sf	or	0.18 Ac.	or	100 %	of Site
	HSG 'D' =	0 sf	or	0 Ac.	or	0 %	of Site

Proposed On-site Impervious Surfaces =	2,203 sf	or	0.05 Ac.

Step 1: Determine ESD Implementation Goals

A. Determine Pre-Developed Conditions:

Soil Conditions and RCNs for "woods in good condition"

HSG	RCN*	Area	Percent
A	38	0.00 Ac.	0.00
B	55	0.00 Ac.	0.00
C	70	0.18 Ac.	100.00
D	77	0.00 Ac.	0.00

* RCN for "woods in good condition" *(Table 2-2, TR-55)*

** Actual RCN is less than 30, use RCN = 38

Composite RCN for "woods in good condition"

RCN_{woods} = [(38x0.00ac)+(55x0.00ac)+(70x0.18ac)+(77x0.00ac)] / 0.18ac

RCN_{woods} = 70

Target RCN for "woods in good condition" = $\boxed{70}$

B. Determine Target P_E Using Table 5.3

P_E = Rainfall used to size ESD practices

Proposed imperviousness (%I)

Proposed Impervious Area: 2,203 sf *from Site Data Table, above*

%I = Imp. Area / Drainage Area = 2,203sf / 7,732sf = 28.49 % = $\boxed{28\ \%}$

- Determine P_E from Table

Hydrologic Soil Group 'A'										
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	40									
5%	43									
10%	46									
15%	48	**38**								
20%	51	40	**38**	**38**						
25%	54	41	40	39						
30%	57	42	41	39	**38**					
35%	60	44	42	40	39					
40%	61	44	42	40	39					
45%	66	48	46	41	40					
50%	69	51	48	42	41	**38**				
55%	72	54	50	42	41	39				
60%	74	57	52	44	42	40	**38**			
65%	77	61	55	47	44	42	40			
70%	80	66	61	55	50	45	40			
75%	84	71	67	62	56	48	40	**38**		
80%	86	73	70	65	60	52	44	40		
85%	89	77	74	70	65	58	49	42	**38**	
90%	92	81	78	74	70	65	58	48	42	**38**
95%	95	85	82	78	75	70	65	57	50	39
100%	98	89	86	83	80	76	72	66	59	40

Use P_E = 0.0 inches of rainfall as the target for ESD implementation

Hydrologic Soil Group 'B'										
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	61									
5%	63									
10%	65									
15%	67	**55**								
20%	68	60	**55**	**55**						
25%	70	64	61	58						
30%	72	65	62	59	**55**					
35%	74	66	63	60	56					
40%	75	66	63	60	56					
45%	78	68	66	62	58					
50%	80	70	67	64	60					
55%	81	71	68	65	61	**55**				
60%	83	73	70	67	63	58				
65%	85	75	72	69	65	60	**55**			
70%	87	77	74	71	67	62	57			
75%	89	79	76	73	69	65	59			
80%	91	81	78	75	71	66	61			
85%	92	82	79	76	72	67	62	**55**		
90%	94	84	81	78	74	70	65	59	**55**	
95%	96	87	84	81	77	73	69	63	57	
100%	98	89	86	83	80	76	72	66	59	**55**

Use P_E = 0.0 inches of rainfall as the target for ESD implementation

Hydrologic Soil Group 'C'											
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	74									
5%	75									
10%	76									
15%	78									
20%	79	**70**								
25%	80	72	**70**	**70**						
30%	81	73	72	71						
35%	82	74	73	72	**70**					
40%	84	77	75	73	71					
45%	85	78	76	74	71					
50%	86	78	76	74	71					
55%	86	78	76	74	71	**70**				
60%	88	80	78	76	73	71				
65%	90	82	80	77	75	72				
70%	91	82	80	78	75	72				
75%	92	83	81	79	75	72				
80%	93	84	82	79	76	72				
85%	94	85	82	79	76	72				
90%	95	86	83	80	77	73	**70**			
95%	97	88	85	82	79	75	71			
100%	98	89	86	83	80	76	72	**70**		

Use P_E = 1.6 inches of rainfall as the target for ESD implementation

Hydrologic Soil Group 'D'											
%I	RCN*	P_E = 1"	1.2"	1.4"	1.6"	1.8"	2.0"	2.2"	2.4"	2.6"
0%	80									
5%	81									
10%	82									
15%	83									
20%	84	**77**								
25%	85	78								
30%	85	78	**77**	**77**						
35%	86	79	78	78						
40%	87	82	81	79	**77**					
45%	88	82	81	79	78					
50%	89	83	82	80	78					
55%	90	84	82	80	78					
60%	91	85	83	81	78					
65%	92	85	83	81	78					
70%	93	86	84	81	78					
75%	94	86	84	81	78					
80%	94	86	84	92	79					
85%	95	86	84	82	79					
90%	96	87	84	82	79	**77**				
95%	97	88	85	82	80	78				
100%	98	89	86	83	80	78	**77**			

Use P_E = 0.0 inches of rainfall as the target for ESD implementation

Compute Composite P_E:

HSG	Area	Target P_E		Net P_E
A	0.00 ac	0.0	0.00 ac x 0.00 / 0.18 ac =	0.0
B	0.00 ac	0.0	0.00 ac x 0.00 / 0.18 ac =	0.0
C	0.18 ac	1.6	0.18 ac x 1.60 / 0.18 ac =	1.6
D	0.00 ac	0.0	0.00 ac x 0.00 / 0.18 ac =	0.0
			Composite P_E =	**1.6**

C. Compute Q_E:

Q_E = Runoff depth used to size ESD practices

$Q_E = P_E * R_V$, where:

P_E = 1.6 in *(from above)*

$R_V = 0.05 + (0.009)(I)$; $I = 28.49$ %

$= 0.05 + 0.009 \times (28.49)$

$= 0.31$

Q_E = 1.6 " x 0.31

= **0.5 inches**

ESD Target for the Project

P_E = **1.6 Inches** *composite P_E, from above*

Q_E = **0.5 Inches**

D. Compute Target ESD_V & Re_V for Drainage Area 6:

Required Environmental Site Design Volume (ESD_V) for DA6:

$$ESD_V = [(P_E) \times (R_V) \times (DA)] / 12$$

where: Target P_E = 1.60 in. *(from Table 5.3, above)*

R_V = 0.31 *(from Q_E, above)*

DA = 7,732 sf or 0.18 ac *(from Site Tabulations, above)*

Target ESD_V = [(1.60 in.) x (0.31) x (7,732 sf)] / 12 =

= **320 cf**

Required Minimum Recharge Volume (Re_V) for DA6:

$$Re_V = [(S) \times (R_V) \times (DA)] / 12$$

Where:

Composite 'S' =

HSG	Area	Recharge Factor		Net 'S'
A	0.00 ac	0.38	0.00 ac x 0.38 / 0.18 ac	0.00
B	0.00 ac	0.26	0.00 ac x 0.26 / 0.18 ac	0.00
C	0.18 ac	0.13	0.18 ac x 0.13 / 0.18 ac	0.13
D	0.00 ac	0.07	0.00 ac x 0.07 / 0.18 ac	0.00
			Composite 'S' =	**0.13**

R_V = 0.31 *from WQ_V, above*

DA = 7,732 sf or 0.18 ac

Min. Re_V = [(0.13) x (0.31) x (7,732)] /12

= **26 cf**

E. Compute P_E Value & ESD_V or Project

DA-6a: ESD Practice M-6 Micro-Bioretention #6

Contributing Drainage Area = 4,752 sf or 0.11 Ac.
Impervious Surfaces in DA = 1,841 sf or 0.04 Ac.
%I = 1,841 sf / 4,752 sf = 39 %
Minimum Surface Area (A_f) = 2% of contributing DA
4,752 sf x 0.02 = 95 sf MINIMUM
Provided Surface Area (A_f) = 168 sf

A_f = 168 sf ≥ 95 sf **O.K.**

Concept Design Estimates:

where: P_E = 15 in x (A_f/DA) *(Eqn 5.2, MDE)*
= 15 in x (168 sf / 4,752 sf)
P_E = **0.53 in.**
R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 39%)
= 0.4
ESD_V = (P_E x R_V x DA)/12
ESD_V = (0.53 in. x 0.40 x 4,752 sf) / 12
= **84 cf** *(Concept Design Estimate)*
Re_V = [(S) x (R_V) x (DA)]/ 12
Where: R_V = 0.05 + (0.009 x %I)
= 0.05 + (0.009 x 39%)
= 0.4
Re_V = [(0.13) x (0.40) x (4,752sf)] /12
= **21 cf**

Final Design Computations: ESD_V based on volume stored in device

Surface area = 168 sf
Filter Media Depth = 2.00 ft
Pea Gravel Depth = 0.50 ft *(6in. of #8 stone for Bridging Layer)*
Gravel Depth = 0.67 ft *(8in. of #57 stone for Gravel Jacket for underdrain)*
Total Media Depth = 3.17 ft

Media Porosity = 0.4
Media Storage Volume = 168sf x 3.17ft. x 0.4
= 213 cf

Ponding Depth = 0.50 ft
Side Slopes = 3:1
Max. Water Surface Area = 252 sf
Ponding Storage Volume = [(252sf + 168sf /2) x 0.50ft.]
= 105 cf
ESD_V Storage provided = 213cf + 105cf
318 cf
P_E Provided = (ESD_V x 12)/(R_V x DA)
= (318cf x 12)/(0.40 x 4,752sf)
= **2.01 in.**

DA-6a: ESD Practice M-9 Enhanced Filter

Filter Bed Area (A_f) = 168 sf *(from above)*
Media Porsity (n) = 0.4 *(#57 stone)*
Depth = 1 ft. *(below invert of underdrain)*
ESD_V Provided = 67 cf
P_E Provided = 0.42 in.

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P_E & ESD_V Summary:

Microscale & Non-Structural Practices						
DA #	ESD Practice	DA	ESD_V	Re_V	P_E Value	Weighted P_E Value
6a	Micro-Bioretention #6	4,752 sf	318 cf	21 cf	2.01 in.	2.01" x 4,752 sf / 7,732 sf = 1.24 in.
6a	Enhanced Filter	4,752 sf	67 cf	67 cf	0.42 in.	0.42" x 4,752 sf / 7,732 sf = 0.26 in.
		Totals:	**385 cf**	**88 cf**		**Total Weighted P_E Value = 1.5 in.**
		Targets:	**320 cf**	**26 cf**		**Target P_E = 1.6 in.**
		ESD_V Provided:	**385 cf**			
		Additional Q_P Storage:	**0 cf**			
P_E Achieved = $(12 \times ESD_V)/(R_V \times AREA)$ =				**(12 x 385c.f.) / (0.31 x 7,732sf) =**		**1.9 in.**

IV. Cp_V, Q_P, & Q_F

Management of the Channel Protection Storage Volume (Cp_V) is not necessary, as the non-structural disconnects and micro-scale practices manage the target ESD_V, and therefore channel protection obligations are met through the Reduced Runoff Curve number Method.

The unmanaged 10-year storm event for the proposed development will not cause erosion, flooding, or any other adverse impact to the outfall at Back Creek; therefore management is not required.

Management of the Extreme Flood Volume (Q_F) is not necessary, as there is no evidence of flooding downstream of the project, and the project is not located within a floodplain.

V. Storm Drain Design

The proposed storm drain system has been designed to convey runoff from the upstream drainage area to the west, tying into the existing system in Bay Ridge Avenue. That system conveys runoff to an existing endwall that outfalls to Back Creek. A new 30" storm drain pipe will be installed in Bay Ridge Avenue to replace the existing 12" pipe there. The following calculations are provided

- C Factors determination
- Time of Concentration calculations
- Flow Tabulation
- Hydraulic Grade Line calculations

rbm

Griscom Square

Anne Arundel County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
D.A. to HW							
SHEET	100	0.0580	0.240				0.153
SHALLOW	530	0.0070	0.050				0.109
SHALLOW	260	0.0130	0.050				0.039
				Time of Concentration			.301 = 18 MIN.

DRAINAGE AREA MAP

SCALE: 1" = 100'

CONSULTANT'S CERTIFICATION

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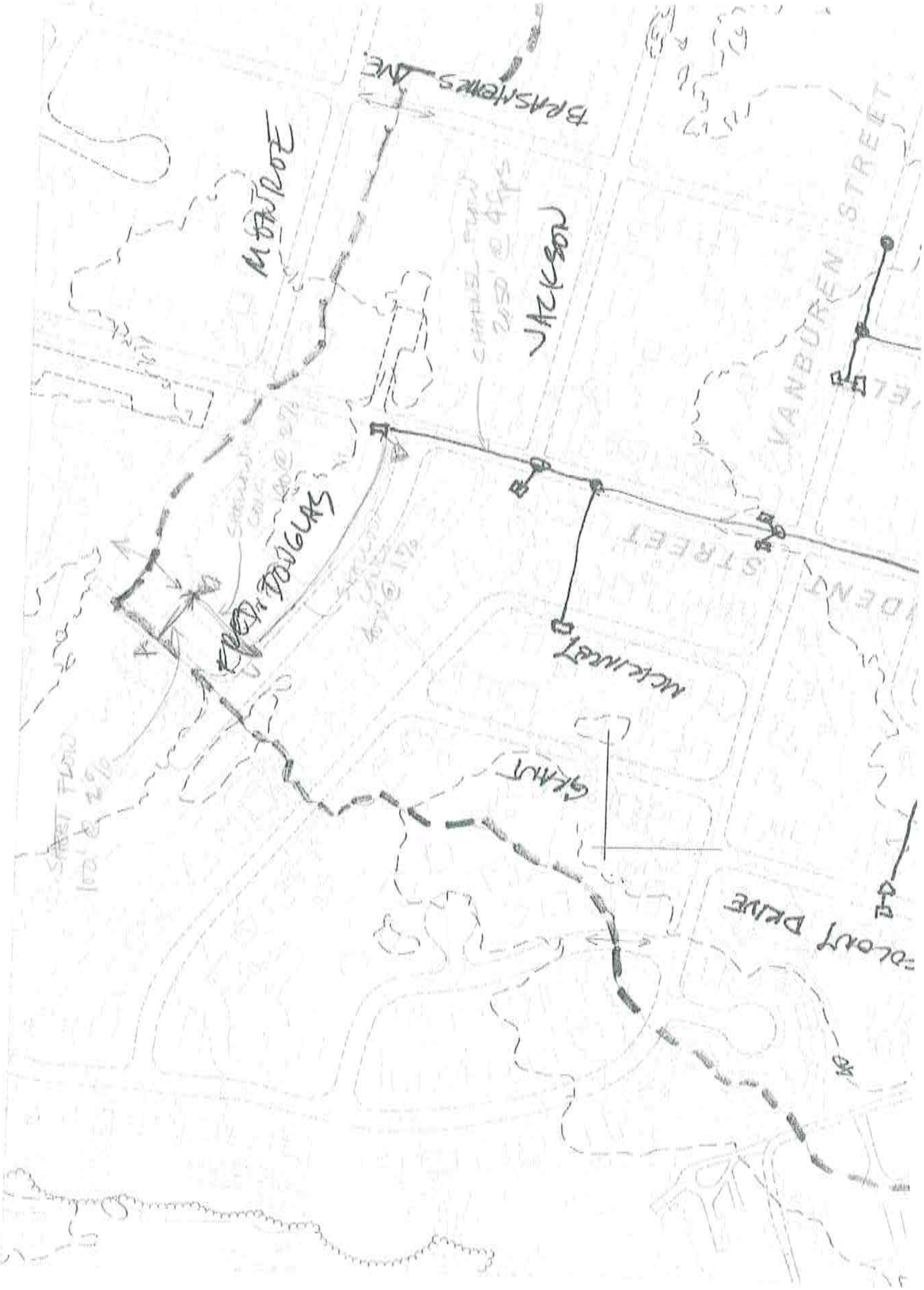
Griscom Square
SD MH-14
Anne Arundel County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length	Slope	Mannings's n	End Area	Wetted Perimeter	Velocity	Travel Time (hr)
D.A. 'S'							
SHEET	100	0.0200	0.240				0.234
SHALLOW	140	0.0200	0.050				0.017
SHALLOW	400	0.0100	0.050				0.069
* CHANNEL	2050					5.000	0.114
				Time of Concentration			.434 = 26 MIN.

* ASSUMED TYPICAL S.D. PIPE FLOW VELOCITY @ 5 fps


MONROE
JACKSON
VANBUREN STREET
FRED DOUGLAS
BRASHEARS LANE
MCKINLEY
GRANT

DRUM, LOYKA & ASSOC, LLC
209 West Street, Suite 203
Annapolis, Maryland 21401
Phone No. (410) 280-3122
Fax No. (410) 280-1952

Project Name:	GRISCOM SQUARE
Project No.:	BP12804
Computed By:	RBM
Checked By:	MMD
Date:	12/1/06
Sheet No.:	1 OF 1

GRISCOM SQUARE
RUNOFF COEFFICIENT 'C'

Drainage or Struct No.	D.A. (Acres)	Land Use* (Surface)	C'	Sub-Area (Acres)	C X A	SCA	CW
A	0.26	Woods	0.35	0.00	0.0000		
		Lawn	0.40	0.15	0.0600		
		Impervious	0.90	0.11	0.0990	0.1590	0.61
B	0.61	Woods	0.35	0.05	0.0175		
		Lawn	0.40	0.51	0.2040		
		Impervious	0.90	0.10	0.0900	0.3115	0.51
C	0.28	Woods	0.35	0.00	0.0000		
		Lawn	0.40	0.22	0.0880		
		Impervious	0.90	0.06	0.0540	0.1420	0.51
D	0.32	Woods	0.35	0.00	0.0000		
		Lawn	0.40	0.23	0.0920		
		Impervious	0.90	0.09	0.0810	0.1730	0.54
E	0.23	Woods	0.35	0.00	0.0000		
		Lawn	0.40	0.14	0.0560		
		Impervious	0.90	0.09	0.0813	0.1373	0.60
F	8.77 (off-site)	Woods	0.35	0.00	0.0000		
		Lawn	0.40	0.00	0.0000		
		R-2 Zoning	0.55	8.77	4.8235	4.8235	0.55
G	0.38	Woods	0.35	0.00	0.0000		
		Lawn	0.40	0.15	0.0600		
		Impervious	0.90	0.23	0.2077	0.2677	0.70
H	0.44	Woods	0.35	0.00	0.0000		
		Lawn	0.40	0.11	0.0440		
		Impervious	0.90	0.33	0.2970	0.3410	0.78
I	0.22	Woods	0.35	0.00	0.0000		
		Lawn	0.40	0.07	0.0280		
		Impervious	0.90	0.15	0.1350	0.1630	0.74
J	0.24	Woods	0.35	0.00	0.0000		
		Lawn	0.40	0.04	0.0160		
		Impervious	0.90	0.20	0.1800	0.1960	0.82
K	0.07	Woods	0.35	0.00	0.0000		
		Lawn	0.40	0.03	0.0120		
		Impervious	0.90	0.04	0.0360	0.0480	0.69
L	0.52	Woods	0.35	0.00	0.0000		
		Lawn	0.40	0.25	0.1000		
		Impervious	0.90	0.27	0.2430	0.3430	0.66
M	0.20	Woods	0.35	0.00	0.0000		
		Lawn	0.40	0.08	0.0320		
		Impervious	0.90	0.12	0.1080	0.1400	0.70

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GRISCOM SQUARE RUNOFF COEFFICIENT 'C'							
Drainage or Struct No.	D.A. (Acres)	Land Use* (Surface)	C'	Sub-Area (Acres)	C X A	SCA	CW
N	0.83	Woods	0.35	0.00	0.0000	0.5370	0.65
		Lawn	0.40	0.42	0.1680		
		Impervious	0.90	0.41	0.3690		
O	0.48	Woods	0.35	0.00	0.0000	0.3370	0.70
		Lawn	0.40	0.19	0.0760		
		Impervious	0.90	0.29	0.2610		
P	0.32	Woods	0.35	0.00	0.0000	0.2080	0.65
		Lawn	0.40	0.16	0.0640		
		Impervious	0.90	0.16	0.1440		
Q	0.22	Woods	0.35	0.00	0.0000	0.1680	0.76
		Lawn	0.40	0.06	0.0240		
		Impervious	0.90	0.16	0.1440		
R	0.37	Woods	0.35	0.00	0.0000	0.2930	0.79
		Lawn	0.40	0.08	0.0320		
		Impervious	0.90	0.29	0.2610		
S	63.52 (off-site)	Woods	0.35	0.00	0.0000	34.9360	0.55
		Lawn	0.40	0.00	0.0000		
		R-2 Zoning	0.55	63.52	34.9360		

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DRUM, LOYKA & ASSOCIATES, LLC
STORM DRAIN FLOW TABULATION FORM

LOCATION GRISCOM SQUARE

DEVELOPMENT

Made in connection with J.O. No. BP12804

STORM FREQUENCY 10 YR/20 YR SUMP

DATE 8/25/2015

SHEET 1 TOTAL IN COMP. 2

COMPUTED BY rbm

CHECKED BY de

LOCATION		AREA	ACRES		COEFF.	CA		ΣCA	TIME CONC.- MIN.			INTEN.		Q=CIA	PIPE n = 0.013				Tc	REMARKS
From	To		Sub.	Total	"C"				Inlet	Drain	Total	"I"		C.F.S.	Size	Sf	Vel.	Lgth.	Min.	
	HW-101	F	8.77	----	0.55	4.82	5.55	----	18.00	----	18.00	5.70	4.95	27.47	----	----	----	----	----	20 yr. Sump
HW-101	I-104	F	----	8.77	----	----		5.55	18.00	0.00	18.00	4.95		27.47	27	0.008	6.91	103	0.25	
	I-104	E	0.23	----	0.60	0.14	0.16	----	5.00	----	5.00	8.00	7.00	1.12	----	----	----	----	----	20 yr. Sump
I-104	I-103	E,F	----	9.00	----	----		5.71	18.00	0.25	18.25	4.90		27.98	27	0.008	7.04	240	0.57	
	I-103	C,D	0.60	----	0.53	0.32	0.37	----	5.00	----	5.00	8.00	7.00	2.56	----	----	----	----	----	20 yr. Sump
I-103	M-103	C-F	----	9.60	----	----		6.08	18.25	0.57	18.82	4.85		29.47	30	0.005	6.00	104	0.29	
	I-107	L	0.52	----	0.66	0.34	0.39	----	5.00	----	5.00	8.00	7.00	2.72	----	----	----	----	----	20 yr. Sump
I-107	M-110	L	----	0.52	----	----		0.39	5.00	0.00	5.00	7.00		2.72	15	0.002	2.22	12	0.09	
	I-108	K	0.07	----	0.69	0.05	0.06	----	5.00	----	5.00	8.00	7.00	0.40	----	----	----	----	----	20 yr. Sump
I-108	M-110	K	----	0.07	----	----		0.06	5.00	0.00	5.00	7.00		0.40	15	0.0000	0.33	18	0.91	
M-110	M-108	K,L	----	0.59	----	----		0.45	5.00	0.91	5.91	6.80		3.06	15	0.002	2.49	27	0.18	
	I-105	J	0.24	----	0.82	0.20	0.23	----	5.00	----	5.00	8.00	7.00	1.60	----	----	----	----	----	20 yr. Sump
I-105	M-109	J	----	0.24	----	----		0.23	5.00	0.00	5.00	7.00		1.60	15	0.001	1.30	11	0.14	
	I-106	I	0.22	----	0.74	0.16	0.18	----	5.00	----	5.00	8.00	7.00	1.28	----	----	----	----	----	20 yr. Sump
I-106	M-109	I	----	0.22	----	----		0.18	5.00	0.00	5.00	7.00		1.28	15	0.0004	1.04	11	0.18	
M-109	M-108	I,J	----	0.46	----	----		0.41	5.00	0.18	5.18	6.95		2.85	15	0.002	2.32	66	0.47	
M-108	M-106	I-L	----	1.05	----	----		0.86	5.91	0.18	6.09	6.80		5.85	18	0.003	3.31	237	1.19	
	I-109	H	0.44	----	0.78	0.34	0.39	----	5.00	----	5.00	8.00	7.00	2.72	----	----	----	----	----	20 yr. Sump
I-109	M-107	H	----	0.44	----	----		0.39	5.00	0.00	5.00	7.00		2.72	15	0.002	2.22	11	0.08	
	I-110	G	0.38	----	0.70	0.27	0.31	----	5.00	----	5.00	8.00	7.00	2.16	----	----	----	----	----	20 yr. Sump
I-110	M-107	G	----	0.38	----	----		0.31	5.00	0.00	5.00	7.00		2.16	15	0.001	1.76	11	0.10	
M-107	M-106	H,G	----	0.82	----	----		0.70	5.00	0.10	5.10	7.00		4.90	15	0.006	3.99	101	0.42	
M-106	M-103	F-L	----	1.87	----	----		1.56	6.09	1.19	7.28	6.55		10.22	18	0.009	5.78	58	0.17	
M-103	M-102	C-L	----	11.47	----	----		7.64	18.82	0.29	19.11	4.80		36.65	30	0.008	7.47	70	0.16	

LOCATION		AREA	ACRES		COEFF.	CA	ΣCA	TIME CONC.- MIN.			INTEN.	Q=CIA	PIPE n = 0.013				Tc	REMARKS
From	To		Sub.	Total	"C"			Inlet	Drain	Total	"I"	C.F.S.	Size	Sf	Vel.	Lgth.	Min.	
	I-102	B	0.61	----	0.51	0.31 0.35	----	5.00	----	5.00	8.00 7.00	2.48	----	----	----	----	----	20 yr. Sump
I-102	M-102	B	----	0.61	----	----	0.35	5.00	0.00	5.00	7.00	2.48	15	0.001	2.02	33	0.27	
	I-101	A	0.26	----	0.61	0.16 0.18	----	5.00	----	5.00	8.00 7.00	1.28	----	----	----	----	----	20 yr. Sump
I-101	M-102	A	----	0.26	----	----	0.18	5.00	0.00	5.00	7.00	1.28	15	0.0004	1.04	8	0.13	
M-102	M-101	A-L	----	12.34	----	----	8.17	19.11	0.16	19.26	4.80	39.23	30	0.009	7.99	142	0.30	
	I-34	O	0.48	----	0.70	0.34	----	5.00	----	5.00	7.00	2.38	----	----	----	----	----	
I-34	I-35	O	----	0.48	----	----	0.34	5.00	0.00	5.00	7.00	2.38	15	0.001	1.94	74	0.64	
	I-35	N	0.83	----	0.65	0.54	----	5.00	----	5.00	7.00	3.78	----	----	----	----	----	
I-35	M-13B	O,N	----	1.31	----	----	0.88	5.00	0.64	5.64	6.90	6.07	15	0.009	4.95	121	0.41	Ex. 15" SD
	I-36	M	0.20	----	0.70	0.14	----	5.00	----	5.00	7.00	0.98	----	----	----	----	----	
I-36	M-13B	M	----	0.20	----	----	0.14	5.00	----	5.00	7.00	0.98	12	0.0004	1.25	19	0.25	Ex 12" CPP
M-13B	M-101	L-O	----	1.51	----	----	1.02	5.64	0.41	6.04	6.80	6.94	18	0.004	3.92	59	0.25	
M-101	M-13	A-O	----	13.85	----	----	9.19	19.26	0.30	19.56	4.75	43.67	30	0.011	8.90	218	0.41	
	I-37	P	0.32	----	0.65	0.21	----	5.00	----	5.00	7.00	1.47	----	----	----	----	----	
I-37	M-11	P	----	0.32	----	----	0.21	5.00	0.00	5.00	7.00	1.47	24	0.0000	0.47	25	0.89	
	I-38	Q	0.22	----	0.76	0.17	----	5.00	----	5.00	7.00	1.19	----	----	----	----	----	
I-38	M-11	Q	----	0.22	----	----	0.17	5.00	0.00	5.00	7.00	1.19	18	0.0001	0.67	37	0.92	
M-11	M-12	P,Q	----	0.54	----	----	0.38	5.00	0.92	5.92	6.80	2.58	24	0.0001	0.82	33	0.67	
	I-39	R	0.41	----	0.79	0.32	----	5.00	----	5.00	7.00	2.24	----	----	----	----	----	
I-39	M-12	R	----	0.41	----	----	0.32	5.00	0.00	5.00	7.00	2.24	18	0.0005	1.27	29	0.38	
M-12	M-13	P-R	----	0.95	----	----	0.70	5.92	0.67	6.59	6.70	4.69	24	0.0004	1.49	44	0.49	
M-13	M-14	A-R	----	14.80	----	----	9.89	19.56	0.41	19.97	4.70	46.50	30	0.013	9.47	222	0.39	
off-site	M-14	S	63.52	----	0.55	34.94	----	26.00	----	26.00	4.00	139.76	54	0.005	8.79	2050	3.89	*Ex.43"x68"
M-14	S-1	A-S	----	78.32	----	----	44.83	26.00	----	26.00	4.00	179.33	66	0.003	7.55	38	0.08	*Ex.53"x83"

HYDRAULIC GRADIENT COMPUTATION FORM

Location	Griscom Square	Date	8/25/2015
Development		Sheet	1
Lot Site		Total in Comp.	
Job Order No.	BP12804	Computed By:	rbm
		Checked By:	de

Tailwater Elevation: 7.00

Crown of Pipe Elevation: 11.42

Hydraulic Gradient: 11.42

From	Outfall	To	MH-14	38	Lin. Ft.	53"x83"	@ 0.28 %		0.11
Structure:		No	MH-14	Type	A	Deflection	0		11.53
Q1	139.76	V1	8.79	LOSSES	A	0.39		Crown =	11.64
Q2	179.27	V2	7.55		B	0.00			
Q3	46.50	V3	9.47		C	0.00			
					D	0.32			
		Q3/Q1 =	33.3%	Total losses		0.71		TOTAL	12.35

From	MH-14	To	MH-13	222	Lin. Ft.	30"	@ 1.42 %		3.15
Structure:		No	MH-13	Type	A	Deflection	0		15.51
Q1	43.67	V1	8.90	LOSSES	A	0.46		Crown =	14.55
Q2	46.50	V2	9.47		B	0.16			
Q3	4.69	V3	1.49		C	0.00			
					D	0.15			
		Q3/Q1 =	10.7%	Total losses		0.77		TOTAL	16.28

From	MH-13	To	MH-101	218	Lin. Ft.	30"	@ 1.12 %		2.44
Structure:		No	MH-101	Type	A	Deflection	90		18.72
Q1	39.23	V1	7.99	LOSSES	A	0.40		Crown =	18.00
Q2	43.67	V2	8.90		B	0.24			
Q3	6.94	V3	3.92		C	0.46			
					D	0.2			
		Q3/Q1 =	17.7%	Total losses		1.30		TOTAL	20.02

From	MH-101	To	MH-102	142	Lin. Ft.	30"	@ 0.91 %		1.29
Structure:		No	MH-102	Type	A	Deflection	0		21.31
Q1	36.65	V1	7.47	LOSSES	A	0.33		Crown =	19.38
Q2	39.23	V2	7.99		B	0.13			
Q3	2.48	V3	2.02		C	0.00			
					D	0.05			
		Q3/Q1 =	6.8%	Total losses		0.50		TOTAL	21.82

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HYDRAULIC GRADIENT COMPUTATION FORM
GRISCOM SQUARE

MH-102 HGL 21.82

From MH-102	To MH-103	70	Lin. Ft.	30"	@	0.79 %	0.55
Structure:	No MH-103	Type	A	Deflection	45		22.37
Q1 29.47	V1 6.00	LOSSES	A	0.28	Crown =		20.00
Q2 36.65	V2 7.47		B	0.31			
Q3 10.22	V3 5.78		C	0.16			
			D	0.15			
Q3/Q1 =	34.7%	Total losses		0.90	TOTAL		23.27

From MH-103	To I-103	104	Lin. Ft.	30"	@	0.51 %	0.53
Structure:	No I-103	Type	D	Deflection	45		23.80
Q1 27.98	V1 7.04	LOSSES	A	0.25	Crown =		21.05
Q2 29.47	V2 6.00		B	0.00			
Q3	V3		C	0.14			
			D				
Q3/Q1 =	0.0%	Total losses		0.39	TOTAL		24.19

From I-103	To I-104	240	Lin. Ft.	27"	@	0.50 %	1.20
Structure:	No I-104	Type	A	Deflection	0		25.39
Q1 27.47	V1 6.91	LOSSES	A	0.25	Crown =		22.15
Q2 27.98	V2 7.04		B	0.03			
Q3	V3		C	0.00			
			D				
Q3/Q1 =	0.0%	Total losses		0.28	TOTAL		25.67

HYDRAULIC GRADIENT COMPUTATION FORM
GRISCOM SQUARE

I-104 HGL 25.67

From I-104 Structure:	To MH-104	24	Lin. Ft.	27"	@	0.78 %		0.19
	No MH-104		Type	A	Deflection	90		25.86
Q1 27.47	V1 6.91		LOSSES	A	0.24		Crown =	26.50
Q2 27.47	V2 6.91			B	0.00			
Q3	V3			C	0.27			
				D				
Q3/Q1 =	0.0%		Total losses		0.51		TOTAL	27.01

From MH-104 Structure:	To MH-105	60	Lin. Ft.	27"	@	0.78 %		0.47
	No MH-105		Type	A	Deflection	90		27.48
Q1 27.47	V1 6.91		LOSSES	A	0.24		Crown =	27.80
Q2 27.47	V2 6.91			B	0.00			
Q3	V3			C	0.27			
				D				
Q3/Q1 =	0.0%		Total losses		0.51		TOTAL	28.31

From MH-105 Structure:	To HW-101	19	Lin. Ft.	34"x22"	@	0.78 %		0.15
	No HW-101		Type	A	Deflection	0		28.46
Q1	V1		LOSSES	A	0.00		Crown =	28.83
Q2	V2			B	0.00			
Q3	V3			C	0.00			
				D				
Q3/Q1 =	#DIV/0!		Total losses		0.00		TOTAL	28.83

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HYDRAULIC GRADIENT COMPUTATION FORM
GRISCOM SQUARE

				MH-102 HGL		21.82	
From MH-102	To I-101	8	Lin. Ft. 15"	@	0.04 %		0.00
Structure:	No I-101	Type D		Deflection	0		21.82
Q1	V1		LOSSES	A	0.00	Crown =	19.78
Q2	V2			B	0.00		
Q3	V3			C	0.00		
				D			
Q3/Q1 =	#DIV/0!		Total losses		0.00	TOTAL	21.82

				MH-102 HGL		21.82	
From MH-102	To I-102	33	Lin. Ft. 15"	@	0.15 %		0.05
Structure:	No I-102	Type D		Deflection	0		21.87
Q1	V1		LOSSES	A	0.00	Crown =	19.71
Q2	V2			B	0.00		
Q3	V3			C	0.00		
				D			
Q3/Q1 =	#DIV/0!		Total losses		0.00	TOTAL	21.87

HYDRAULIC GRADIENT COMPUTATION FORM
GRISCOM SQUARE

MH-103 HGL 23.27

From	MH-103	To	MH-106A	47	Lin. Ft.	18"	@	0.94 %	0.44
Structure:		No.	MH-106A	Type	A	Deflection	45		23.71
Q1	10.22	V1	5.78	LOSSES	A	0.17	Crown =		25.95
Q2	10.22	V2	5.78		B	0.00			
Q3		V3			C	0.09			
					D				
	Q3/Q1 =		0.0%	Total losses		0.26	TOTAL		26.21

From	MH-106A	To	MH-106	11	Lin. Ft.	18"	@	0.94 %	0.10
Structure:		No.	MH-106	Type	A	Deflection	0		26.31
Q1	5.85	V1	3.31	LOSSES	A	0.17	Crown =		26.11
Q2	10.22	V2	5.78		B	0.35			
Q3	4.90	V3	3.99		C	0.00			
					D	0.05			
	Q3/Q1 =		83.8%	Total losses		0.57	TOTAL		26.89

From	MH-109	To	MH-108	237	Lin. Ft.	18"	@	0.31 %	0.73
Structure:		No.	MH-108	Type	A	Deflection	0		27.62
Q1	3.06	V1	2.49	LOSSES	A	0.06	Crown =		27.40
Q2	5.85	V2	3.31		B	0.07			
Q3	2.85	V3	2.32		C	0.00			
					D	0.05			
	Q3/Q1 =		93.1%	Total losses		0.18	TOTAL		27.80

From	MH-108	To	MH-110	27	Lin. Ft.	15"	@	0.22 %	0.06
Structure:		No.	MH-110	Type	A	Deflection	45		27.86
Q1	2.72	V1	2.22	LOSSES	A	0.03	Crown =		27.65
Q2	3.06	V2	2.49		B	0.02			
Q3	0.40	V3	0.33		C	0.02			
					D	0.01			
	Q3/Q1 =		14.7%	Total losses		0.08	TOTAL		27.94

HYDRAULIC GRADIENT COMPUTATION FORM
GRISCOM SQUARE

MH-110 HGL 27.94

From MH-110	To I-107	12	Lin. Ft.	15"	@	0.18 %		0.02
Structure:	No I-107	Type	WR	Deflection	0			27.96
Q1		V1		LOSSES	A	0.00	Crown =	28.05
Q2		V2			B	0.00		
Q3		V3			C	0.00		
					D			
	Q3/Q1 =	#DIV/0!		Total losses		0.00	TOTAL	28.05

MH-110 HGL 27.94

From MH-110	To I-108	18	Lin. Ft.	15"	@	0.01 %		0.00
Structure:	No I-108	Type	WR	Deflection				27.94
Q1		V1		LOSSES	A	0.00	Crown =	28.05
Q2		V2			B	0.00		
Q3		V3			C	0.00		
					D			
	Q3/Q1 =	#DIV/0!		Total losses		0.00	TOTAL	28.05

MH-108 HGL 27.80

From MH-108	To MH-109	66	Lin. Ft.	15"	@	0.19 %		0.13
Structure:	No MH-109	Type	A	Deflection	45			27.93
Q1	1.60	V1	1.30	LOSSES	A	0.03	Crown =	27.73
Q2	2.85	V2	2.32		B	0.06		
Q3	1.28	V3	1.04		C	0.02		
					D	0.04		
	Q3/Q1 =	80.0%		Total losses		0.14	TOTAL	28.07

From MH-109	To I-106 & 105	11	Lin. Ft.	15"	@	0.06 %		0.01
Structure:	No I-106 & I-106	Type	D	Deflection	0			28.08
Q1		V1		LOSSES	A	0.00	Crown =	27.89
Q2		V2			B	0.00		
Q3		V3			C	0.00		
					D			
	Q3/Q1 =	#DIV/0!		Total losses		0.00	TOTAL	28.08

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HYDRAULIC GRADIENT COMPUTATION FORM
GRISCOM SQUARE

				MH-106 HGL		26.89	
From MH-106	To MH-107	101 Lin. Ft.	15"	@	0.57 %		0.58
Structure:	No. MH-107	Type A	Deflection	45			27.46
Q1 2.72	V1 2.22	LOSSES	A	0.08	Crown =		27.48
Q2 4.90	V2 3.99		B	0.17			
Q3 2.16	V3 1.76		C	0.04			
			D	0.03			
Q3/Q1 =	79.4%	Total losses		0.33	TOTAL		27.81

From MH-107	To I-109 & 110	11 Lin. Ft.	15"	@	0.18 %		0.02
Structure:	No. I-109 & 110	Type WR	Deflection				27.83
Q1	V1	LOSSES	A	0.00	Crown =		27.69
Q2	V2		B	0.00			
Q3	V3		C	0.00			
			D				
Q3/Q1 =	#DIV/0!	Total losses		0.00	TOTAL		27.83

VI. Downstream Analysis

Runoff from this site will be treated for water quality and recharge prior to being conveyed via the storm drain system to an existing 43" x 68" storm drain pipe on the east side of Bay Ridge Avenue, approximately 250 feet north of Tyler Avenue. The runoff discharges from an existing headwall at the head of a channel which discharges into Back Creek. The outfall at the headwall is stabilized with a riprap apron. The meandering channel is generally stable with minor signs of erosion. The overbank areas are wooded with dense undergrowth. The existing outfall area will remain stable upon completion of this project.

PHOTO #1 - 53" x 83" RCP

PHOTO #2 - 53" x 83" RCP OUTFALL

PHOTO #3 -
STABILIZED SLOPES DOWNSTREAM OF PIPE OUTFALL

PHOTO #4 - STREAM BED

PHOTO #5 - STREAM BED

PHOTO #6 - STREAM BED

PHOTO #7 - STREAM BED

PHOTO #8 - STREAM OUTFALL AT BACK CREEK

Appendix A - Geotechnical Report – Marshall Engineering

MARSHALL ENGINEERING, INC.

GEOTECHNICAL ENGINEERS

3161 Solomons Island Road, Suite 2 · Edgewater, MD 21037
(410)956-7820 · FAX (410)956-1537

John P. Marshall, P.E. — *President*
Robert A. O'Berry — *Geotechnical Engineer*
Lisa P. Carroll — *Project Manager*

April 5, 2006

John Pilli
197 Hanover Street
Annapolis, MD 21401

Re: Geotechnical Investigation
Proposed SWM/Infiltration
1402 Bay Ridge Road
Anne Arundel County, MD
MEI Job No. 06074

Mr. Pilli:

Submitted here is the report of our geotechnical investigation at the above-referenced site. The purpose of this study was to determine the suitability of the subsurface profile at locations specified by your engineer, Dave Grimm of Drum, Loyka & Associates, LLC, (Drum/Loyka) for the use of infiltration for stormwater management design.

FIELD INVESTIGATION

To determine the subsurface conditions, five hand auger borings (labeled B-1 through B-5) were made to depths of 12 to 16 feet below the existing ground surface. The boring locations were staked by representatives from Drum/Loyka. Soil technicians made the borings, visually inspected and classified the soils encountered and also obtained samples for subsequent classification by our geotechnical staff. Boring Logs, a Boring Plan and the laboratory test results are attached. On the Logs, the soil classifications are based on the USDA Textural Triangle with the Group Symbol based on the Unified Soils Classification System (USCS) also included.

PVC pipes were installed at all five of the boring locations so that infiltration tests could be performed to measure permeability. The depths of the tests were established to be above ground/perched water and within deposits considered possibly suitable for infiltration. Information concerning each test installation is given on the appropriate boring log. The infiltration tests were done in accordance with current Anne Arundel County and Maryland Department of the Environment (MDE) requirements. A summary of each test is also attached.

GENERAL SUBSURFACE CONDITIONS

Based on the Geologic Map of Anne Arundel County, prepared by the Maryland Geologic Survey, the geologic profile at the site consists of the Aquia Formation. In general, the subsurface profile at the boring locations, to the maximum depths investigated, 12 to 16 feet, consists of layered Sandy Loams (SM, SC-SM) and Sandy Clay Loams with some random Sandy Clay (SC-CL) and Clay Loam (CL) layers. Surficial deposits of Fill and/or Possible Fill [Fill?] soils, defined herein as material that had visual evidence it might be Fill but no positive indicators, were encountered at all the boring locations, except B-3, ranging in depths from 4 to 6 feet. Water was encountered at the locations of Borings B-4 and B-5 at depths of 13 and 13.5 feet, respectively. Perched water was noted at the locations of Borings B-1, B-2 and B-4 at depths of between 4 and 5 feet and moist to very moist soil conditions were noted throughout the subsurface profile at all of the boring locations. It is noted that ground/perched water levels may vary at different times due to seasonal changes, precipitation and local runoff.

Given below is a general summary of the profile at Borings B-1 through B-5 relative to infiltration potential.

Boring No.	Depth	Description	Infiltration Potential*
B-1	0'-4'	Intermixed Sandy Loam and Sandy Clay Loam [Fill]	Poor
	4'-5'	Sandy Loam [Fill?]	Slow
	5'-12'**	Sandy Clay Loam	Poor

Boring No.	Depth	Description	Infiltration Potential*
B-2	0'-3'	Sandy Clay Loam [Fill]	Poor
	3'-4'	Clay Loam [Fill]	Unsuitable
	4'-6'	Intermixed Sandy Clay Loam and Sandy Loam [Fill?]	Poor
	6'-7'	Sandy Clay Loam	Poor
	7'-8'	Sandy Clay Loam with Clay Loam layers	Unsuitable
	8'-10'	Sandy Clay Loam	Poor
	10'-11.5'**	Layered Sandy Loam and Sandy Clay Loam	Poor
	11.5'-12'	Sandy Loam	Slow
B-3	0'-2'	Sandy Clay	Unsuitable
	2'-5'	Sandy Clay Loam	Poor
	5'-7'	Sandy Loam to Sandy Clay Loam	Slow/Poor***
	7'-11'**	Sandy Loam	Slow
	11'-12'	Sandy Loam	Slow
B-4	0'-2'	Sandy Loam [Fill?]	Slow
	2'-4'	Sandy Clay Loam [Fill?]	Poor
	4'-5'	Sandy Loam [Fill?]	Slow
	5'-9'	Sandy Clay Loam	Poor
	9'-11'**	Sandy Loam	Slow
	11'-13'	Sandy Loam w/thin Sandy Clay Loam layers	Slow/Poor***
	13'	Water encountered	
B-5	0'-4'	Sandy Loam [Fill?]	Slow
	4'-6'	Sandy Clay Loam	Poor
	6'-8'	Sandy Clay Loam w/Clay Loam layers	Unsuitable
	8'-10'	Sandy Loam w/thin Sandy Clay Loam layers	Slow/Poor***
	10'-11.5'**	Sandy Loam	Slow
	11.5'-13'	Sandy Loam w/thin Sandy Clay Loam layers	Slow/Poor***
	13'-13.5'	Sandy Loam	Slow
	13.5'	Water encountered	

* *Relative Permeability Ratings by Marshall Engineering, Inc.:*

Poor = Not considered suitable for infiltration (can be due to thin layers).
Slow = Probably suitable, but slow (Prel. I = 1.0 in./hr.)
Good = Probably suitable (Prel. I = 2.5 in./hr.)

** *Performed Infiltration Testing in this layer.*

*** *Where a dual infiltration potential is provided, the slower infiltration rate should be used for design unless field infiltration can verify a higher rate.*

The permeability classification and preliminary infiltration rates ("I") given above are based on information from DNR publications which relate infiltration rates to soil classification based on the USDA Textural Triangle and our experience with similar soil types and conditions.

Concerning actual infiltration rates, reference is made to the attached Infiltration Test Summary. The results of our infiltration testing are tabulated below.

Boring Number	Test Depth	Soil Description	Tested Infiltration Range (in./hr.)
B-1	8'	Sandy Clay Loam	0.1 to 0.2
B-2	11'	Layered Sandy Loam and Sandy Clay Loam	0.0 to 0.2
B-3	8.5'	Sandy Loam	1.8 to 4.3
B-4	10'	Sandy Loam	1.1 to 2.8
B-5	10'	Sandy Loam	2.7 to 3.9

CONCLUSIONS & RECOMMENDATIONS

It is concluded from this investigation that portions of the subsurface profile at the locations of borings B-3, B-4 and B-5 are suitable for the use of infiltration for stormwater management. The design rates listed below can be used for design of any infiltration system situated within the Sandy Loam deposits and conforming with current Anne Arundel County and MDE requirements. Due to the presence of thin Sandy Clay Loam layers within some of the Sandy Loam deposits these design rates are contingent upon the installation of an overflow device. It is noted that some of the Sandy Loam soils within the upper subsurface profile at the location of Boring B-5 are noted as Possible Fill soils. Test pits are recommended at this location in order to confirm the results of our soil borings concerning extent, content and condition of the Possible Fill soils.

Boring No.	Depth*	Description	Design Infiltration Rate (in./hr.)
B-3	7'-12'	Sandy Loam	1.02**
B-4	9'-14'	Sandy Loam w/thin Sandy Clay Loam layers	1.02**
B-5	0'-4' 8'-13.5'	Sandy Loam [Fill?] Sandy Loam w/thin Sandy Clay Loam layers	1.02** 1.02**

**Adjustments in the SWM device depth may be required to consider the presence of ground/perched water, ironstone layers or soils with slower infiltration rates below this depth based on Anne Arundel County/MDE requirements.*
*** Based on the installation of an overflow device*

The design infiltration rates are slower than the final measured infiltration rates to account for the possible slower rates of some of the layered soils and the presence of Possible Fill. Thin Sandy Clay Loam layers exist within the deeper profiles at the locations of Borings B-4 and B-5 from depths of 9 to 12 feet and 8 to 12 feet, respectively, that may limit vertical infiltration. However, it has been our experience (verified by field testing) that lateral infiltration should also be considered within this type of profile. It is also noted that, at the location of Boring B-4, perched water was encountered at a depth of 4 to 5 feet and may need to be considered in the design of any infiltration system. The upper subsurface profiles at the locations of Borings B-3 and B-4 as well as the entire profiles at the locations of Borings B-1 and B-2 are unsuitable for the use of infiltration for stormwater management due to soils with unsuitable infiltration rates.

A Geotechnical Engineer should inspect the subgrade of any infiltration system designed on the basis of this report in order to compare the subsurface conditions with those encountered in the borings and used for design. This is essential due to the Possible Fill conditions noted in the upper subsurface profiles at some of the boring locations. If conditions are not the same, changes may be necessary.

REMARKS

This report was compiled based solely on the results of the soil test borings performed at the project site. The recommendations were developed from the information obtained in the test borings which depict subsurface conditions only at these specific locations and at the particular time designated on the logs. Soil conditions at other locations may differ from conditions occurring at these boring locations. Also, the passage of time may result in a change in the soil conditions at the boring locations.

The nature and extent of variations between the borings may not become evident until the time of construction. If variations become evident, it will be necessary to re-evaluate the recommendations in this report after performing on-site observations during the excavation period and noting the characteristics of any variation. However, only minor variations that can be readily evaluated and adjusted during construction are expected.

Our professional services have been performed, our findings obtained and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. This warranty is in lieu of all other warranties either expressed or implied. This company is not responsible for the conclusions, opinions or recommendations made by others based on this data. If during construction, any problems or deviations are encountered contrary to our findings, Marshall Engineering, Inc. should be notified immediately.

We have appreciated this opportunity to provide our services to you on this project. If we can be of any further assistance, please do not hesitate to contact our office.

Very truly yours,
MARSHALL ENGINEERING, INC.

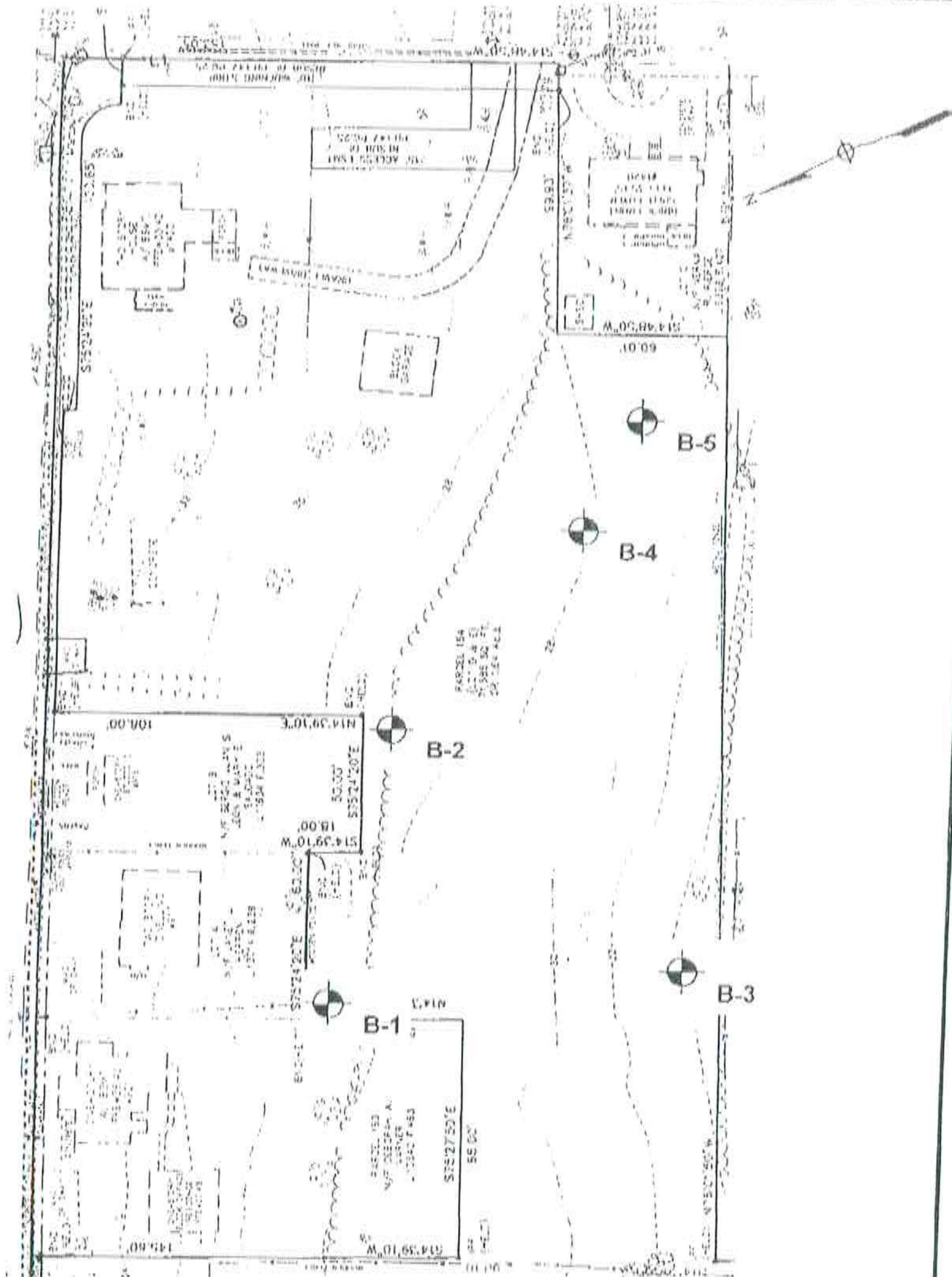
John P. Marshall, P.E.
President

STATE OF MARYLAND
JOHN P. MARSHALL
No. 8202
REGISTERED
PROFESSIONAL ENGINEER

Lisa P. Carroll
Project Manager

JPM/LPC:mcc
Copies: Client – Mail (1)
Drum/Loyka; Attn. Dave Grimm – Mail (2); FAX (1)

BORING PLAN AND LOGS



MARSHALL ENGINEERING, INC.
GEOTECHNICAL ENGINEERS
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JOB NAME:	1402 BAY RIDGE AVENUE
SHEET TITLE:	BORING PLAN
PREPARED BY: AMJ	JOB NO.: 06074
DATE: 03/27/06	SHEET NO.: D1

HAND AUGER SUMMARY
BORING NO.: B-1

PROJECT: 1402 Bay Ridge Avenue
CLIENT: John Pilli
LOCATION: See Boring Plan

PROJECT NO.: 06074
DATE: 03/26/06
ELEVATION: 29'+
LOGGED BY: LPC

DEPTH TO WATER> AT COMPLETION: Dry — AFTER .5 HOURS: Dry
DEPTH TO CAVE-IN> AT COMPLETION: None — AFTER .5 HOURS: None

ELEVATION/ DEPTH	SOIL SYMBOLS, SAMPLERS AND TEST DATA	USCS		Description	NM%	DYNAMIC CONE PENETROMETER TEST DEPTH	N	CURVE 3 6 9 12
0		Fill		Intermixed Very Moist Olive Brown f-m Sandy Loam (SC-SM) and Sandy Clay Loam (SC) w/trace ironstone and shell fragments [Fill]				
27.5					29			
2.5				- w/trace organics below 2'				
					28			
25		SM	4.0	Wet Olive Brown Sandy Loam (SM) [Fill?]				
5		SC	5.0	Moist to Very Moist Olive Brown and Gray Sandy Clay Loam (SC)	18			
22.5				- reddish olive brown and olive brown below 6'				
7.5					26			
20								
					24			
10								
17.5					21			
			12.0	Bottom of Boring 12'				
12.5								
15								
15								
12.5								

To perform infiltration test, made boring to 8' and installed PVC pipe at location +10' from this boring. Sealed around annulus space at bottom with bentonite pellets and water.

This information pertains only to this boring and should not be interpreted as being indicative of the site

Marshall Engineering, Inc.

HAND AUGER SUMMARY

BORING NO.: B-2

PROJECT: 1402 Bay Ridge Avenue
CLIENT: John Pilli
LOCATION: See Boring Plan

PROJECT NO.: 06074
DATE: 03/26/06
ELEVATION: 28'±
LOGGED BY: LPC

DEPTH TO WATER> AT COMPLETION: Dry — AFTER 1 HOURS: Dry
DEPTH TO CAVE-IN> AT COMPLETION: None — AFTER 1 HOURS: None

ELEVATION	DEPTH	USCS	Layer bottom	Description	NM%	DYNAMIC CONE PENETROMETER TEST DEPTH	N	CURVE (3, 6, 9, 12)
27.5	0	Fill	3.0	Moist to Very Moist Olive Brown and Brown Sandy Clay Loam (SC) [Fill] - olive brown below 2'	20			
25	2.5	Fill	4.0	Very Moist Olive Brown and Brown Clay Loam (CL) w/trace pieces of metal [Fill]	34			
22.5	5	SC-SM	6.0	Intermixed Very Moist Olive Brown, Brown and Black Sandy Clay Loam (SC) and Sandy Loam (SM) w/trace organics [Fill?] - wet below 5'				
20	7.5	SC	10.0	Moist to Very Moist Olive Brown Sandy Clay Loam (SC) - w/Clay Loam (CL) layers from 7'-8' - w/Sandy Loam (SC-SM) layers below 8'	21 22			
17.5	10	SC-SM	11.5	Layered Very Moist Olive Brown Sandy Loam (SC-SM) and Sandy Clay Loam (SC)	21			
15	12.5	SM	12.0	Very Moist Reddish Olive Brown Sandy Loam (SM) Bottom of Boring 12'				
12.5	15							

To perform infiltration test, made boring to 11' and installed PVC pipe at location +10' from this boring. Sealed around annulus space at bottom with bentonite pellets and water.

This information pertains only to this boring and should not be interpreted as being indicative of the site.

Marshall Engineering, Inc.

HAND AUGER SUMMARY

BORING NO.: B-3

PROJECT: 1402 Bay Ridge Avenue
CLIENT: John Pilli
LOCATION: See Boring Plan

PROJECT NO.: 06074
DATE: 03/26/06
ELEVATION: 34'±
LOGGED BY: LPC

DEPTH TO WATER> AT COMPLETION: Dry — AFTER 2 HOURS: Dry
DEPTH TO CAVE-IN> AT COMPLETION: None — AFTER 2 HOURS: None

ELEVATION/ DEPTH	SOIL SYMBOLS, SAMPLERS AND TEST DATA	USCS		Description	NM%	DYNAMIC CONE PENETROMETER TEST DEPTH	N	CURVE 3 6 9 12
0		SC-CL		Moist to Very Moist Olive Brown Sandy Clay (SC-CL)				
32.5					25			
2.5		SC	2.0	Moist to Very Moist Olive Brown Sandy Clay Loam (SC)				
30				- w/Sandy Loam (SC-SM) layers below 4'	26			
5		SC-SM	5.0	Very Moist Olive Brown Sandy Loam (SC-SM) to Sandy Clay Loam (SC)	19			
27.5								
7.5		SC-SM	7.0	Moist to Very Moist Dark Reddish Olive Brown Sandy Loam (SC-SM) w/trace ironstone fragments	19			
25				- very moist below 10'	19			
10								
22.5		SM	11.0	Moist Reddish Olive Brown Sandy Loam (SM)	15			
12.5			12.0	Bottom of Boring 12'				
20								
15								
17.5								

To perform infiltration test, made boring to 8.5' and installed PVC pipe at location +10' from this boring. Sealed around annulus space at bottom with bentonite pellets and water.

This information pertains only to this boring and should not be interpreted as being indicative of the site.

Marshall Engineering, Inc.

HAND AUGER SUMMARY

BORING NO.: B-4

PROJECT: 1402 Bay Ridge Avenue
CLIENT: John Pilli
LOCATION: See Boring Plan

PROJECT NO.: 06074
DATE: 03/26/06
ELEVATION: 28'±
LOGGED BY: LPC

DEPTH TO WATER> AT COMPLETION: Dry — AFTER 24 HOURS: 13.0'
DEPTH TO CAVE-IN> AT COMPLETION: None — AFTER 24 HOURS: 14.5'

ELEVATION/ DEPTH	SOIL SYMBOLS, SAMPLERS AND TEST DATA	USCS		Description	NM%	DYNAMIC CONE PENETROMETER TEST DEPTH	N	CURVE (3 6 9 12)
27.5 / 0		SC-SM		Very Moist Olive Brown Sandy Loam (SC-SM) [Fill?]				
25 / 2.5		SC	2.0	Moist to Very Moist Olive Brown Sandy Clay Loam (SC) [Fill?] - very moist w/trace organics below 3'	29			
		SM	4.0	Wet Tan and Gray Sandy Loam (SM) [Fill?]				
22.5 / 5		SC	5.0	Moist to Very Moist Reddish Olive Brown and Olive Brown Sandy Clay Loam (SC)	25			
20 / 7.5					21			
17.5 / 10		SC-SM	9.0	Moist to Very Moist Reddish Olive Brown Sandy Loam (SC-SM) - w/thin Sandy Clay Loam (SC) layers below 11'	16 20			
15 / 12.5		SM	13.0	Wet Olive Brown Sandy Loam (SM) w/trace ironstone fragments				
12.5 / 15			16.0	Bottom of Boring 16'				

To perform infiltration test, made boring to 10' and installed PVC pipe at location ±10' from this boring. Sealed around annulus space at bottom with bentonite pellets and water.

This information pertains only to this boring and should not be interpreted as being indicative of the site.

Marshall Engineering, Inc.

HAND AUGER SUMMARY

BORING NO.: B-5

PROJECT: 1402 Bay Ridge Avenue
CLIENT: John Pilli
LOCATION: See Boring Plan

PROJECT NO.: 06074
DATE: 03/26/06
ELEVATION: 29.5'+
LOGGED BY: LPC

DEPTH TO WATER> AT COMPLETION: Dry — AFTER 24 HOURS: 13.5'
DEPTH TO CAVE-IN> AT COMPLETION: None — AFTER 24 HOURS: 14.0'

ELEVATION/ DEPTH	SOIL SYMBOLS, SAMPLERS AND TEST DATA	USCS		Description	NM%	DYNAMIC CONE PENETROMETER TEST DEPTH	N	CURVE 3 6 9 12
0		SM		Moist to Very Moist Olive Brown Sandy Loam (SM) w/trace organics [Fill?]	14			
27.5 / 2.5					14			
25 / 5		SC	4.0	Very Moist Olive Brown Sandy Clay Loam (SC) - moist to very moist below 5' - w/Clay Loam (CL) layers below 6'	22			
22.5 / 7.5					24			
20 / 10		SC-SM	8.0	Moist to Very Moist Olive Brown Sandy Loam (SC-SM) w/thin Sandy Clay Loam (SC) layers	18			
17.5 / 12.5		SM	10.0	Moist to Very Moist Reddish Olive Brown Sandy Loam (SM) - w/thin Sandy Clay Loam (SC) layers from 11.5'-13' - wet with trace ironstone fragments below 14'	17			
15 / 15								
12.5			16.0	Bottom of Boring 16'				

To perform infiltration test, made boring to 10' and installed PVC pipe at location ±10' from this boring. Sealed around annulus space at bottom with bentonite pellets and water.

This information pertains only to this boring and should not be interpreted as being indicative of the site

Marshall Engineering, Inc.

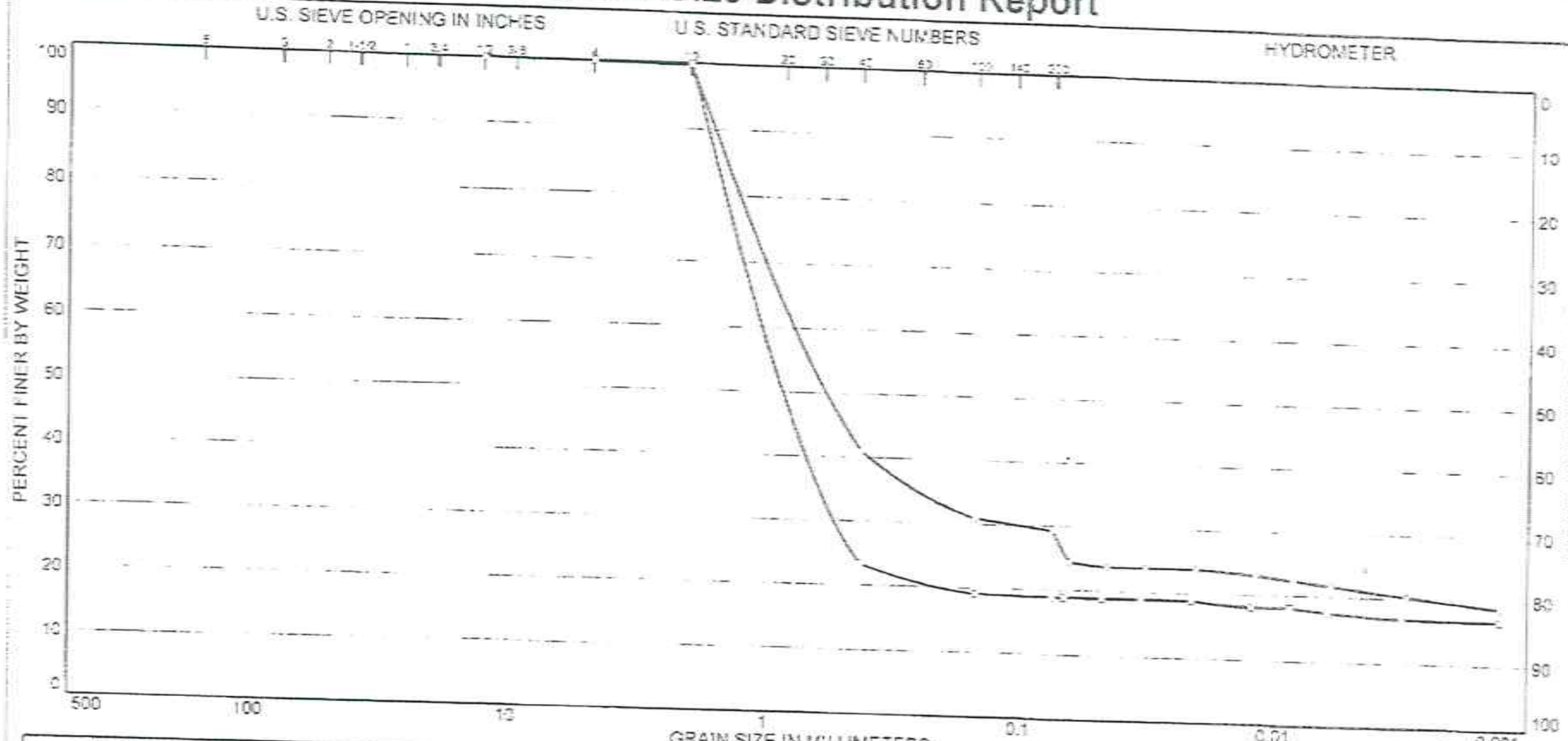
FIELD AND LABORATORY TESTING

INFILTRATION TEST SUMMARY

1402 Bay Ridge Road
Anne Arundel County, MD
April 5, 2006

Boring Number	Test Depth	Time Duration (min.)	Infiltration Rate (In./Hr.)
B-1	8'	60	0.2
		60	0.2
		60	0.1
		60	0.1
B-2	11'	60	0.2
		60	0.1
		60	0.1
		60	0.0
B-3	8.5'	60	4.3
		60	3.1
		60	2.6
		60	1.8
B-4	10.0'	60	2.8
		60	2.4
		60	1.9
		60	1.1
B-5	10.0'	60	3.9
		60	3.2
		60	2.7
		60	2.7

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.1	75.9	4.5	19.5
0.0	0.0	81.1	2.2	16.7

SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PL
B-3	S-8	8'	03/28/06	SC-SM	Dark Reddish Olive Brown Sandy Loam w/ trace ironstone fragments			
B-4	S-10	10'	03/28/06	SM	Reddish Olive Brown Sandy Loam			

Client: John Pilli

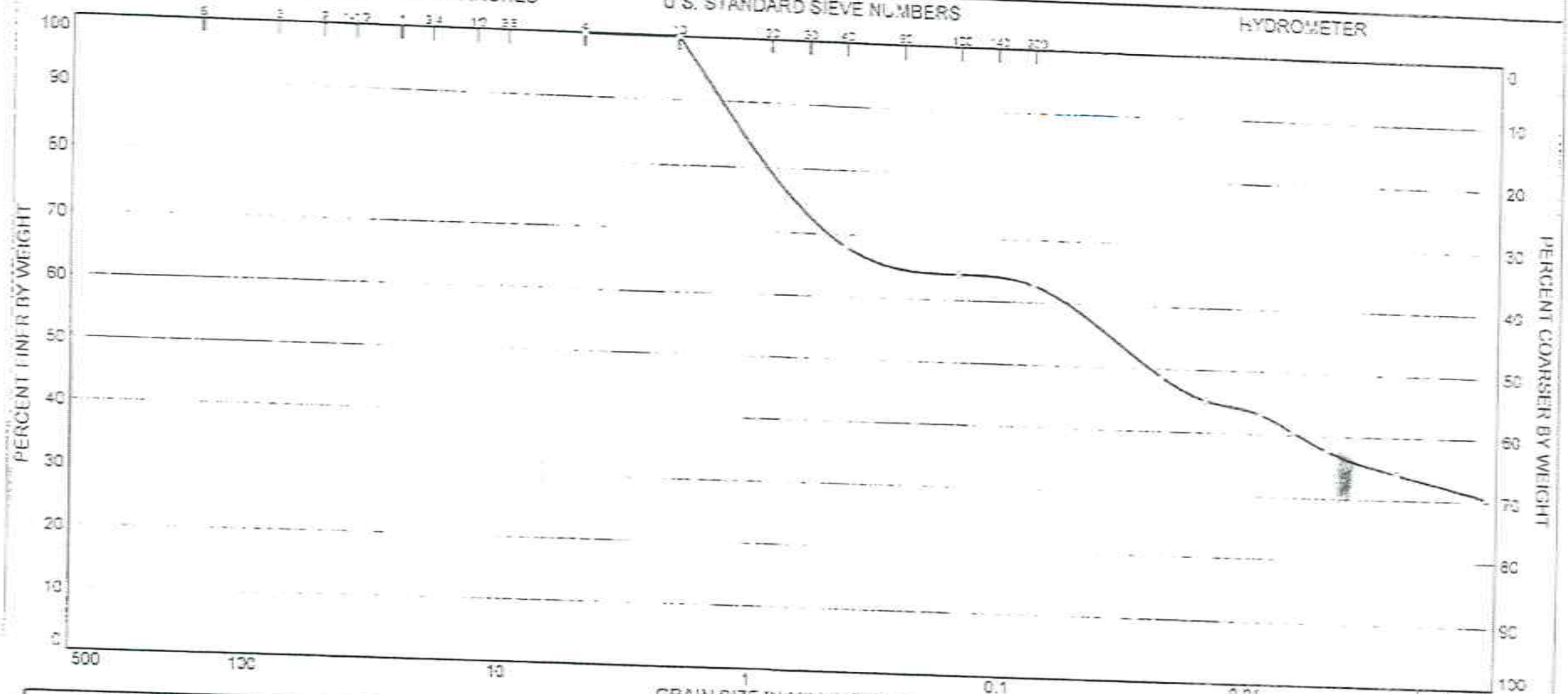
Project: 1402 Bay Ridge Avenue

Project No.: 06074

Plate

MARSHALL ENGINEERING, INC.

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	40.4	26.5	33.1

SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PL
B-5	S-6	6'	03/28/06	CL	Olive Brown Clay Loam layer			

Client: John Pilli

Project: 1402 Bay Ridge Avenue

Project No. 06074 Plate

MARSHALL ENGINEERING, INC.

Appendix B - Geotechnical Report – O'Berry Engineering

O'BERRY ENGINEERING, INC.

GEOTECHNICAL ENGINEERING • CONSTRUCTION INSPECTION

3161 Solomons Island Road, Suite 2 · Edgewater, MD 21037
(410) 956-7820 · FAX (410) 956-1537
obei@oberryengineering.com

Robert A. O'Berry, P.E.
President

Lisa P. Carroll
Project Manager

July 13, 2015

Pilli Development Company, Inc.
197 Hanover Street
Annapolis, Maryland 21401
Attention: John Pilli

Re: Geotechnical Investigation
Proposed SWM/Infiltration
Griscom Square
Anne Arundel County (Annapolis), MD
OBEI Job No. 15059

Mr. Pilli:

Submitted here is the report of our geotechnical investigation performed at the referenced site. The purpose of this study was to determine the suitability of the subsurface profile at locations specified by your engineer, Drum, Loyka and Associates, LLC (Drum), for the use of infiltration for stormwater management.

FIELD INVESTIGATION

To determine the subsurface conditions, four borings (identified as SWM-1 through SWM-4) were performed to a depth of 15 feet below the existing ground surface. The boring locations were staked by Drum. Soil technicians augered the borings, visually inspected and classified the soils encountered and also obtained samples for subsequent classification by our geotechnical staff. A Boring Plan and the Boring Logs are attached. On the logs, the soils have been classified using the USDA Textural Triangle with the group symbol based on the USCS also included. The depths given on each log were referenced from the existing ground surface at the time of our investigation. Elevations at the boring locations were taken from the site plan provided to our office by Drum.

LABORATORY AND FIELD TESTING

Laboratory Sieve/Hydrometer tests were performed on selected samples from the borings to help establish textural classification for determining infiltration rates and other soil properties. The results of these tests are plotted as gradation curves on the attached "Particle Size Distribution Report" form. Shown on the boring logs are natural moisture contents of selected samples taken from the borings.

After completion of the borings and review of their results, PVC pipes were installed near three of the boring locations so that infiltration tests could be performed to measure permeability. Information concerning each test installation is given on the appropriate boring log. The infiltration tests were performed in general accordance with current Anne Arundel County and Maryland Department of the Environment (MDE) requirements.

GENERAL SUBSURFACE CONDITIONS

Based on the Geologic Map of Anne Arundel County, prepared by the Maryland Geologic Survey, the geologic profile at this site consists of the Aquia Formation. Generally, the subsurface profile at the boring locations consists of layered Loamy Sand (SM), Sandy Clay Loam (SC) and Sandy Loam (SC-SM) deposits. Observations concerning water were made while augering the borings, at completion of the borings and 24 hours after completion of the borings as indicated on the boring logs. Water was encountered at the locations and depths noted on the following general summary of the profile. It is noted that water levels may vary at different times due to seasonal changes, precipitation and local runoff.

Given below and on the following page is a general summary of the profile at the SWM boring locations relative to infiltration potential.

Boring No.	Depth	Soil Description	Infiltration Potential*
SWM-1	0' – 1.5'	Loamy Sand	Good
	1.5' – 8.5'	Sandy Clay Loam	Poor
	8.5' – 10.5'	Loamy Sand	Good
	10.5' – 15'**	Sandy Loam	Slow

Boring No.	Depth	Soil Description	Infiltration Potential*
SWM-2	0' – 10.5'	Sandy Clay Loam	Poor
	10.5' – 11.5'	Sandy Loam	Slow
	11.5' – 13.5'	Loamy Sand w/Sandy Clay Loam layers below 12.5'	Good/Poor***
	13.5'	Water encountered at 13.5'	
SWM-3	0' – 1.5'	Loamy Sand	Good
	1.5' – 6.5'	Sandy Clay Loam	Poor
	6.5' – 9.5'**	Sandy Loam w/Sandy Clay Loam layers below 8.5'	Slow/Poor***
	9.5' – 11.5'	Loamy Sand w/thin ironstone layers below 10.5'	Good/Poor***
	11.5' – 13.5'	Sandy Loam w/random thin ironstone layers	Slow/Poor***
	13.5'	Water encountered at 13.5'	
SWM-4	0' – 1.5'	Loamy Sand	Good
	1.5' – 4.5'	Sandy Clay Loam	Poor
	4.5' – 8.5'	Sandy Loam	Slow
	8.5' – 14.5'**	Loamy Sand	Good
	14.5'	Water encountered at 14.5'	

* *Relative Permeability Ratings by O'Berry Engineering, Inc.:*

Poor = Not considered suitable for infiltration (can be due to thin unsuitable soil or ironstone layers).
Slow = Probably suitable, but slow (Prel. I = 1.02 in./hr.)
Good = Probably suitable (Prel. I = 2.5 in./hr.)

** *Infiltration Testing performed in this layer.*

*** *Where a dual infiltration potential is provided, the slower infiltration rate should be used for design unless field infiltration can verify a higher rate.*

The permeability classification and preliminary infiltration rates ("I") given above are based on information from DNR publications which relate infiltration rates to soil classification based on the USDA Textural Triangle and our experience with similar soil types and conditions. The results of our field infiltration testing are tabulated below.

Boring No.	Test Depth	Test El.	Soil Description	Tested Infiltration Range (in./hr.)
SWM-1	11.5'	19.1'	Sandy Loam	1.4 to 1.9
SWM-3	8.0'	23.2'	Sandy Loam	0.1 to 1.0
SWM-4	9.5'	22.7'	Loamy Sand	1.8 to 3.0

CONCLUSIONS AND RECOMMENDATIONS

It is concluded from this investigation that portions of the subsurface profile at the locations of Borings SWM-1 and SWM-4 are suitable for the use of infiltration for stormwater management. The design infiltration rate listed below can be used for design of any infiltration system situated within the natural Sandy Loam or Loamy Sand deposits and conforming to current Anne Arundel County and MDE requirements. It is noted that these rates are contingent on the placement of any overflow device.

Boring No.	Depth*	Description	Design Infiltration Rate (in./hr.)
SWM-1	8.5' – 15'	Loamy Sand/Sandy Loam	1.02**
SWM-4	4.5' – 14.5'	Sandy Loam/Loamy Sand	1.02**

* *Adjustments in the SWM device depth based on Anne Arundel County/MDE requirements may be required to consider the presence of groundwater and soils with slower infiltration rates below this depth or the depth to the bottom of the boring.*

** *Contingent on the placement of an overflow device.*

The remaining profile at these boring locations, as well as the entire subsurface profile at the remaining boring locations, is unsuitable for the use of infiltration for stormwater management due soils with unsuitable infiltration rates, high soil moisture contents and/or groundwater.

A Geotechnical Engineer should inspect the subgrade of any infiltration system designed on the basis of this report in order to compare the subsurface conditions with those encountered in the borings and used for design. If conditions are not the same, changes may be necessary.

REMARKS

This report was compiled based solely on the results of the soil test borings performed at the project site. The recommendations were developed from the information obtained in the test borings which depict subsurface conditions only at these specific locations and at the particular time designated on the logs. Soil conditions at other locations may differ from conditions occurring at these boring locations. Also, the passage of time may result in a change in the soil conditions at the boring locations.

The nature and extent of variations between the borings may not become evident until the time of construction. If variations become evident, it will be necessary to re-evaluate the recommendations in this report after performing on-site observations during the excavation period and noting the characteristics of any variation. However, only minor variations that can be readily evaluated and adjusted during construction are expected.

Our professional services have been performed, our findings obtained and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. This warranty is in lieu of all other warranties either expressed or implied. This company is not responsible for the conclusions, opinions or recommendations made by others based on this data. If during construction, any problems or deviations are encountered contrary to our findings, O'Berry Engineering, Inc. should be notified immediately.

We have appreciated this opportunity to provide our services to you on this project. If we can be of any further assistance, please do not hesitate to contact our office.

Respectfully,
O'BERRY ENGINEERING, INC.

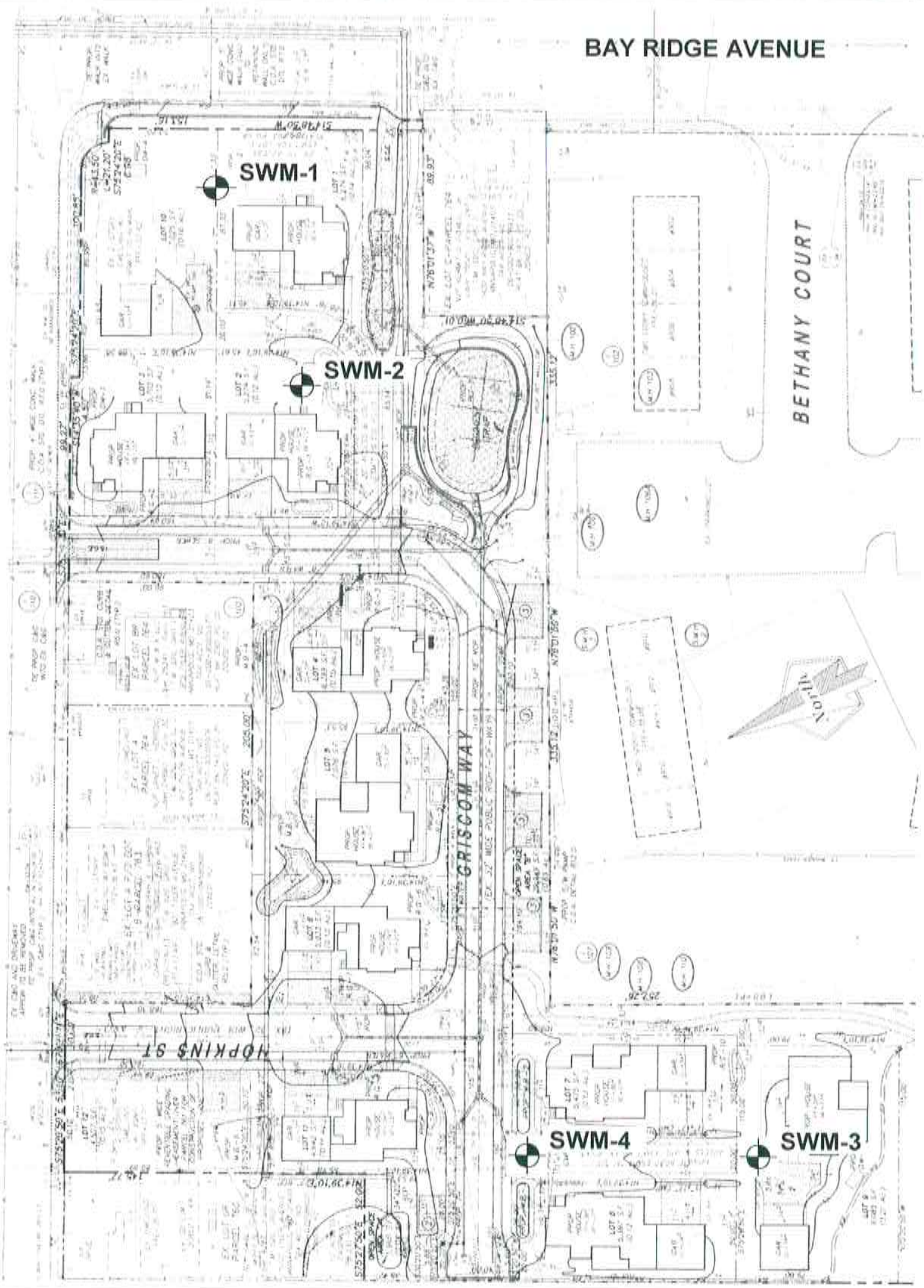
STATE OF MARYLAND
ROBERT A. O'BERRY
Lic. No. 33338
PROFESSIONAL ENGINEER

Robert A. O'Berry, P.E.
President

Lisa P. Carroll
Project Manager

RAO/LPC
Copies: Client – Mail (2), email – jpilli@gateonebuilders.com
Drum, Attn. Bill Bower – email bbower@drumloyka.com

BORING PLAN AND BORING LOGS



O'BERRY ENGINEERING, INC.
GEOTECHNICAL ENGINEERING
3161 Solomons Island Road, Suite 2
Edgewater, MD 21037
Phone: (410) 956-7820 • Fax: (410) 956-1537

JOB NAME: GRISCOM SQUARE			SHEET NO.: D-1
SHEET TITLE: BORING PLAN			
PREPARED BY: LPC	JOB NO.: 15059	DATE: 7/2/15	

HAND AUGER SUMMARY

BORING NO.: SWM-1

PROJECT: Griscom Square
CLIENT: Pilli Development Company, Inc.
LOCATION: See Boring Plan

PROJECT NO.: 15059
DATE: 6/16/15
ELEVATION: 30.6'
LOGGED BY: RAO

DEPTH TO WATER > AT COMPLETION: Dry — AFTER 24 HOURS: Dry
DEPTH TO CAVE-IN > AT COMPLETION: None — AFTER 24 HOURS: None

ELEVATION/ DEPTH	USCS	Depth	Description	NM%	DEPTH
0	SM	1.5	Damp to Moist Brown Loamy Sand (SM)	6	
1.5	SC	8.5	Moist to Very Moist Olive Brown Sandy Clay Loam (SC) -moist below 2.5' -very moist below 5.5'	14 13 19	
8.5	SM	10.5	Very Moist Olive Brown Loamy Sand (SM) -moist below 9.5'	17	
10.5	SC-SM	15.0	Moist Olive Brown Sandy Loam (SC-SM)	14 13	
15.0			Bottom of Boring 15'		

Elevation scale: 30, 27.5, 25, 22.5, 20, 17.5, 15; Depth scale: 0, 2.5, 5, 7.5, 10, 12.5, 15, 17.5

To perform infiltration test, made boring to 11.5' and installed PVC pipe at location 10'± from this boring. Sealed around annulus space at bottom with bentonite pellets and water.

This information pertains only to this boring and should not be interpreted as being indicative of the site.

O'Berry Engineering, Inc.

HAND AUGER SUMMARY

BORING NO.: SWM-2

PROJECT: Griscom Square
CLIENT: Pilli Development Company, Inc.
LOCATION: See Boring Plan

PROJECT NO.: 15059
DATE: 6/16/15
ELEVATION: 29.4'
LOGGED BY: RAO

DEPTH TO WATER> AT COMPLETION: Dry AFTER 24 HOURS: 13.5'
DEPTH TO CAVE-IN> AT COMPLETION: None AFTER 24 HOURS: None

ELEVATION/ DEPTH	SOIL SYMBOLS, SAMPLERS AND TEST DATA	USCS		Description	NM%	DEPTH
0		SC		Moist to Very Moist Olive Brown Sandy Clay Loam (SC)	17	
27.5 / 2.5					14	
25 / 5					15	
22.5 / 7.5					17	
20 / 10			10.5		17	
		SC-SM	11.5	Moist to Very Moist Reddish Olive Brown Sandy Loam (SC-SM)	13	
17.5 / 12.5		SM		Very Moist Reddish Olive Brown Loamy Sand (SM) -olive brown w/Sandy Clay Loam (SC) layers below 12.5' -very moist to wet below 13.5'	18	
15 / 15			15.0	Bottom of Boring 15'		
12.5 / 17.5						

This information pertains only to this boring and should not be interpreted as being indicative of the site.

O'Berry Engineering, Inc.

HAND AUGER SUMMARY

BORING NO.: SWM-3

PROJECT: Griscom Square
CLIENT: Pilli Development Company, Inc.
LOCATION: See Boring Plan

PROJECT NO.: 15059
DATE: 6/16/15
ELEVATION: 31.2'
LOGGED BY: RAO

DEPTH TO WATER> AT COMPLETION: Dry AFTER 24 HOURS: 13.5'
DEPTH TO CAVE-IN> AT COMPLETION: None AFTER 24 HOURS: None

USCS	Layer bottom (ft)	Description	NM%
SM	1.5	Moist Brown Loamy Sand (SM)	12
SC	6.5	Moist Olive Brown Sandy Clay Loam (SC) w/trace ironstone fragments -moist to very moist below 4.5'	15, 17
SC-SM	9.5	Very Moist Reddish Olive Brown Sandy Loam (SC-SM) -w/Sandy Clay Loam (SC) layers below 8.5'	19, 21
SM	11.5	Very Moist Olive Brown Loamy Sand (SM) -w/thin ironstone layers below 10.5'	22
SC-SM	15.0	Very Moist to Wet Reddish Olive Brown Sandy Loam (SC-SM) w/random thin ironstone layers -w/Loamy Sand (SM) layers below 13.5'	23
		Bottom of Boring 15'	

To perform infiltration test, made boring to 8' and installed PVC pipe at location 10'± from this boring. Sealed around annulus space at bottom with bentonite pellets and water.

This information pertains only to this boring and should not be interpreted as being indicative of the site.

O'Berry Engineering, Inc.

HAND AUGER SUMMARY

BORING NO.: SWM-4

PROJECT: Griscom Square
CLIENT: Pilli Development Company, Inc.
LOCATION: See Boring Plan

PROJECT NO.: 15059
DATE: 6/16/15
ELEVATION: 32.2'
LOGGED BY: RAO

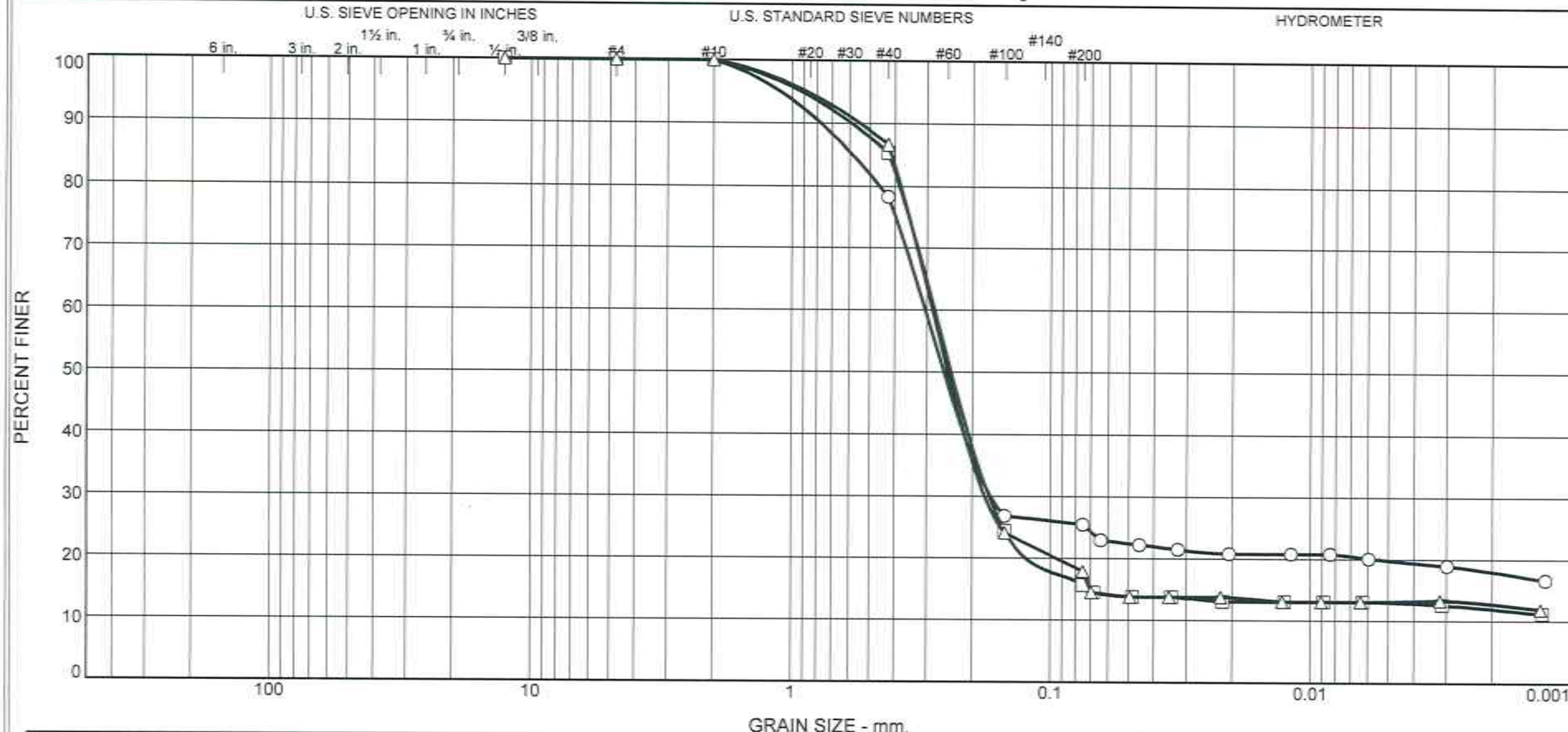
DEPTH TO WATER> AT COMPLETION: Dry — AFTER 24 HOURS: Dry
DEPTH TO CAVE-IN> AT COMPLETION: None — AFTER 24 HOURS: 14.5'

ELEVATION/ DEPTH	SOIL SYMBOLS, SAMPLERS AND TEST DATA	USCS		Description	NM%	DEPTH
0		SM	1.5	Moist to Very Moist Brown Loamy Sand (SM)	12	
30 / 2.5		SC	4.5	Moist to Very Moist Olive Brown Sandy Clay Loam (SC)	18	
27.5 / 5; 25 / 7.5		SC-SM	8.5	Moist Olive Brown Sandy Loam (SC-SM) -very moist below 6.5'	13 18	
22.5 / 10; 20 / 12.5; 17.5 / 15		SM	15.0	Very Moist Olive Brown Loamy Sand (SM) -reddish olive brown 11.5' -wet below 14.5'	18 19 16	
15 / 17.5				Bottom of Boring 15'		

To perform infiltration test, made boring to 9.5' and installed PVC pipe at location 10'± from this boring. Sealed around annulus space at bottom with bentonite pellets and water.

This information pertains only to this boring and should not be interpreted as being indicative of the site.

Particle Size Distribution Report



	% Stones	% +3"	% Gravel			% Sand					% Silt		% Clay
			Coarse	Medium	Fine	V. Crs.	Crs.	Med.	Fine	V. Fine	Crs.	Fine	
○	0.0	0.0	0.0	0.0	0.0	6.3	11.8	33.7	22.1	3.5	1.7	2.9	18.0
□	0.0	0.0	0.0	0.0	0.0	4.2	8.0	35.6	34.4	3.9	0.8	1.1	12.0
△	0.0	0.0	0.0	0.0	0.0	3.8	7.3	38.7	29.7	6.6	0.2	0.9	12.8

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	SWM-1	S-13	13'	6/22/15	SC-SM	Olive Brown Sandy Loam			
□	SWM-3	S-10	10'	6/22/15	SM	Olive Brown Loamy Sand			
△	SWM-4	S-11	11'	6/22/15	SM	Olive Brown Loamy Sand			

Client Pilli Development Co., Inc.

Project Griscom Square

Project No. 15059

Figure

O'Berry Engineering, Inc.